PB-219 670

WASTEWATER TREATMENT STUDIES IN AGGREGATE AND CONCRETE PRODUCTION

Robert G. Monroe

Smith and Monroe and Gray Engineers, Incorporated

Prepared for:

Environmental Protection Agency

February 1973

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5285 Port Royal Road, Springfield Va. 22151

W73-08126

PB 219 670

EPA-R2-73-003
FEBRUARY 1973

Environmental Protection Technology Series

Wastewater Treatment Studies in Aggregate and Concrete Production

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SELECTED WATER RESOURCES ABSTRACTS
INPUT TRANSACTION FORM

1. Report No. | 2. | 3. Accession No. W73-08126

4. Title
WASTEWATER TREATMENT STUDIES IN AGGREGATE AND CONCRETE PRODUCTION,

5. Report Date

6.

7. Author(s)
Monroe, R. G.

8. Performing Organization Report No.

9. Organization
Smith and Monroe and Gray Engineers, Inc~~orporated~~
Lake Oswego, Oregon.

10. Project No. EPA Project #12080 HBM

11. Contract/Grant No.
~~16080 HBM~~

13. Type of Report and Period Covered

12. ~~Sponsoring Organization~~ ~~Oregon Concrete and Aggregate Producers Association, Incorporated Research Grant~~ ~~Section 6~~

15. Supplementary Notes
Environmental Protection Agency Technology Series report number, EPA-R2-73-003, February 1973. 108 p, 45 fig, 3 tab, ~~Project 16080 HBM~~ 4 ref, 3 append.

16. Abstract

~~This report contains~~ discussions are presented of various water clarification systems used in the aggregate and ready-mixed concrete industries. The overall problem of waste water disposition in each type of plant is studied. An analysis is made of the use of settling ponds, filter ponds and coagulants. Recycling and use of recycled water is discussed with recommendations for further study of the potential use of waste water from ready-mix plants for concrete batch water. Since many aggregate and ready-mix concrete plants now have effective clarification or recycling systems the overall purpose of the study is to make these systems known throughout the industry so proven systems can be made available to all. The report is based on a review of systems in reported 77 plants and firms plus data obtained from a field trip inspection of 88 plants on the West Coast. The study contains 45 charts and photographs of clarification systems. (EPA)

17a. Descriptors * Waste water treatment, *Aggregates, ~~*Settling Ponds,~~ *Filters, ~~Ponds,~~ *Coagulation, ~~*Ready-Mix~~ *Settling Basins, ~~Manufactured~~ Equipment, ~~Acid Treatment, Reuse in Mix,~~ Water Reuse, *Water purification, Treatment facilities, *Concrete plants

17b. Identifiers
Aggregate Settling Ponds, Ready-Mix Settling Basins, ~~Coagulation~~ Filter ponds, Acid treatment

Copy available from GPO Sup Doc as I 19.23/2:, $1.25; microfiche from NTIS as PB 219 670, $0.95.

17c. COWRR Field & Group 05D, 08F

18. Availability ✓

19. Security Class. (Report)

20. Security Class. (Page)

21. No. of Pages

22. Price $27,400

Send To: WATER RESOURCES SCIENTIFIC INFORMATION CENTER U.S. DEPARTMENT OF THE INTERIOR WASHINGTON, D. C. 20240

Abstractor Robert G. Monroe | Institution Smith & Monroe & Gray Engineers, Inc

WRSIC 102 (REV. JUNE 1971)

GU.S. GOVERNMENT PRINTING OFFICE: 1973 514-153/192 1-3

EPA-R2-73-003
February 1973

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OFFICE OF RESEARCH AND MONITORING
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
Price $1.25 domestic postpaid or $1 GPO Bookstore

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ABSTRACT

This report contains discussions of various water clarification systems used in the aggregate and ready-mixed concrete industries. The overall problem of waste water disposition in each type of plant is studied. An analysis is made of the use of settling ponds, filter ponds and coagulants. Recycling and use of recycled water is discussed with recommendations for further study of the potential use of waste water from ready-mix plants for concrete batch water. Since many aggregate and ready-mix concrete plants now have effective clarification or recycling systems the overall purpose of the study is to make these systems known throughout the industry so proven systems can be made available to all. The report is based on a review of systems in reported 77 plants and firms plus data obtained from a field trip inspection of 88 plants on the West Coast. The study contains 45 charts and photographs of clarification systems.

This report was submitted in fulfillment of Grant 12080 HBM under the sponsorship of the Office of Research and Monitoring, Environmental Protection Agency.

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SECTION I

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

The aggregate and ready-mixed concrete industries are primarily smaller businesses producing a low cost product. Probably for this reason, these industries have not had the development in water clarification technology as in many other industries. Thorough research needs to be made in handling, clarifying and reuse or recycling of the waste water.

The one area that became apparent first and which appears to be one of the greatest importance is that of evaluating the effects of using wash water as mix water in concrete. The small amount of testing which has been done thus far, points to encouraging results. It is expected that all the wash water could be reused in this type of system and no waste water would be discharged.

Research and experimentation should be made to design and develop efficient methods of water clarification for the various types of plants.

The aggregate industry uses much more water and has a somewhat more difficult problem than does the ready-mix concrete industry. Additional study is needed to develop inexpensive closed loop systems for the aggregate industry. The closed loop system is desirable because the water does not need to be completely clarified to be acceptable as wash water. The natural or manmade filter ponds show a great deal of promise, but current information is not complete enough to be of measurable value to operators. Study in this area would require construction of test models as well as design research.

Plant operators are also in need of more knowledge regarding the handling of waste water. The information needed includes proper pump selection, required slope on pipe lines to avoid settlement, proper methods for handling the very wet sediment, as well as possible commercial uses for the wet sediment.

Water clarification equipment is being developed very rapidly at this time. The industry could benefit by having each product explained, evaluated and tested so the plant operators could choose the best equipment for their use. Chemicals are being used to settle suspended particles out of the water. The effects of these chemicals on the effluent water and on the product quality should be studied.

Each of the above mentioned areas of needed study should be extensive to develop the in-depth answers required.

SECTION II

INTRODUCTION

This study was carried out through grant funds from The Environmental Protection Agency and sponsorship of The Oregon Concrete and Aggregate Producers Association, under Grant No. 12080 HBM. The aggregate and ready-mixed concrete industries use many gallons of water each year, some of which adds to the national water pollution problem. The basic purpose of the study is to provide a state-of-the-art survey of aggregate and ready-mix production to determine the kind and extent of present treatment methods for the process water.

The study was conducted in four phases as follows:

Phase I--Surveyed the available literature pertaining to water pollution caused by aggregate and ready-mix production and the total national water pollution problem.

Phase II--The main purpose of this phase was to determine the kind and extent of present treatment methods for process water used in aggregate and ready-mix production. The literature was reviewed. In addition, questionnaires were submitted to principal aggregate and ready-mix producers, and inspections were made in a selected number of aggregate and ready-mix plants.

Phase III--Gaps in technology were identified during this phase and recommendations for further research were developed.

Phase IV--All the information developed in the first three phases was assembled and the effective systems described in this report.

SECTION III

WATER USAGE IN UNITED STATES

Water in the United States is used primarily for irrigation, public water supply, domestic, industrial and steam-electric power. Not all the water used in these areas creates pollution. In general, one third of the water returns to the waterway with the salt content approximately doubled. One third is consumed in making products or is lost in the atmosphere. One third becomes contaminated with organic and inorganic solids originating in the process water.

It is the latter one third of this water with which the aggregate and ready-mixed concrete industries are concerned. This report defines these industries to include sand and gravel, crushed stone and ready-mixed concrete plants.

Before looking at the specific water pollution problems and solutions it becomes necessary to compare overall water consumption by the major classifications of users. Sand and gravel production in the United States in 1969 totaled 937 million short tons valued at $1,070,000,000. Crushed stone production in the United States in 1969 totaled 861 million short tons valued at $1,326,047,000.

Many sand and gravel and crushed stone plants need no washing in producing their finished product. Other plants must use up to 800 gallons of water per ton of production. Because many plants use no water, the average water demand per plant is only 70 gallons per ton. About 126 billion gallons of water is used per year in processing sand and gravel and crushed stone.

The ready-mixed concrete industry takes this processed material and adds cement, special additives and water. This mixture becomes active concrete which will begin to set within a few hours, so trucks and other plant equipment must be continually washed clean to prevent build-up of concrete and the break down of machinery. There are approximately 8,000 ready-mixed concrete plants in the United States with a national production of 186,000,000 cubic yards per year. This mixed concrete is valued at $2,930,000,000. Water used for making the product amounts to six billion gallons per year. Since this water is totally consumed in the product it does add to the national water usage, but not to water pollution. The water

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TABLE 1

PERCENTAGE OF WATER USAGE IN UNITED STATES

Year	Irrig	Public Water Supply	Domestic	Steam Electric Power	--Industry-- Aggreg	Total	Total Gal/Year Trillion
1960	43	7	2	25	.23	23	39.0
1965	41	7	2	26	.24	24	45.0
1970	39	7	2	27	.25	25	50.5
1975	37	7	2	29	.25	25	56.6
1980	35	7	2	30	.26	26	66.2
1985	33	7	2	31	.27	27	75.0

used to wash the trucks and equipment does become a potential water pollutant.

The average ready-mix truck load is 6.8 cubic yards and each truck averages 4.2 trips per day. Each truck and its portion of the plant equipment will use an average of 500 gallons of water per day.

The range of water use per truck per day varies widely because some operators wash out trucks once a day, while others wash out after each load. Availability of water also affects usage. When water is abundant and low in cost, operators use larger quantities. However, they wash off about the same amount of solids in any case, so the potential stream pollution load is not increased. Based on 500 gallons per day the annual water usage is as follows:

$$\text{Annual wash water} = \frac{186{,}000{,}000 \text{ yards/year} \cdot 500 \text{ gal/day}}{6.8 \text{ yards/load} \cdot 4.2 \text{ loads/day}}$$

$$= 4 \text{ billion gallons/year.}$$

The aggregate and ready-mixed concrete industries used 136 billion gallons of water in 1969 and the rate is increasing by four per cent per year. This figure agrees closely with other surveys showing the stone and vitreous products using two per cent of the total industrial water. The aggregate and ready-mix concrete industries amount to about one-half of the total stone and vitreous products.

This analysis gives a perspective of the volume of water used by the aggregate and ready-mixed concrete industries and the comparison to the total water use. The analysis shows that although the aggregate and ready-mixed concrete industries are heavy water users, they use only a small percentage of the total water used in the United States.

Water is used by everyone as a carrier of product or waste, for cooling, for washing, for irrigation, for addition to products and many other uses. Most all of these uses change the water characteristics if no clarification or treatment is made. The change in the water quality varies widely even within a specific industry. Effluent water from food processing plants, sewage treatment plants and other similar operations may produce harmful bacteria, reduce dissolved oxygen and produce undesirable appearances. Plastic, chemical and oil industries may discharge oil or toxic substances, increase temperatures and produce many other undesirable characteristics. Aggregate and ready-mix plants may raise the pH factor, increase turbidity and reduce the dissolved oxygen.

Each year, from the aggregate produced, the aggregate producing industry washes off many tons of fine sand, silts and clays. Waste water from the ready-mix industry contains fine sand, lime and cement. The uncontrolled and untreated discharge from both of these industries impairs the aesthetic quality of our streams and may be a nazard to marine life.

With the increase in production of these industries, an additional volume of water is required of approximately four per cent per year. The requirements for cleaner products require more thorough washing and scrubbing which in turn increases the amounts of suspended particles in the waste water. This increase in volume and concentration of suspended particles in the effluent water can only add to the existing problem. The aggregate and ready-mixed concrete industries, as well as all other water users, must have clarification systems in order to improve the quality of water which they discharge into our streams and rivers.

Many of these plants do have effective systems for clarifying the water or recycling it. It is the purpose of this study to make these systems known to all the industry so proven systems can be put into operation quickly.

SECTION IV

AGGREGATE PLANT WASTE WATER DISPOSITION

Letters were written to 56 Ready-Mixed Concrete and Aggregate Producers' state associations explaining this study and asking for a list of their membership from whom information could be sought. From 31 responses, 350 letters and questionnaires were sent to individual companies. The summary present herewith is based on responses from 77 companies. To augment responses from these questionnaires a field trip was made to 88 plants on the West Coast.

A preliminary assumption could be made that only a few plants are concerned about the waste water problem or there would have been a greater response to the letters and questionnaires. However, after reviewing the returned questionnaires and visiting plant sites throughout the area, impressive evidence was obtained that most plants are more or less self-contained and have no actual figures or data pertaining to the condition of their water or amounts used. This is why they did not fill out and return the form.

Most plants are located on the outskirts of towns and have sites consisting of from several to many acres of ground upon which they have been operating for many years. Most of them have abandoned pits or low areas on their own sites into which they discharge their waste water and waste material. The plant is in this sense self-contained and has at this time no water clarification problem. Many plants also have both aggregate and ready-mixed concrete operations on the same site. There is no way to estimate the proportion of these plants to the total number of plants. Because of this it seems more logical and realistic to analyze the methods of water clarification individually rather than attempting to translate them into percentages within the total industry.

The aggregate industry uses water primarily to wash out the silts, clays and foreign materials from the raw material and to separate out the excess fines in the classification of the saleable product. The amount of water needed per ton of material will vary with each site of operation as well as within different areas and strata on the same site. It is dependent upon the amount of contaminants that need to be scrubbed off or washed from the product and the amount of fines that may have to be separated out.

Plant equipment needed for removing these foreign materials and fines consists of washing screens, log washers, sand screens and classifiers. The amounts and kinds of foreign materials in the pit or quarry determine the kinds and sizes of the equipment needed in the plant which in turn determines the amount of water required. Sources of aggregate may vary from relatively pure material requiring little or no washing to material too contaminated to process economically. However, in some parts of the country, the lack of sufficient sources of sand and gravel to meet the need for the product may require the use of those pits or quarries whose material requires extensive cleaning and separation of these foreign materials. Use of water therefore varies from five to ten gallons per ton to 500 or more gallons per ton of material processed.

The water discharged from the plants varies from a light to heavy concentration of suspended particles ranging from fine sand to silts and clays to colored pigments. Methods of clarifying this waste water vary from use of a simple settling basin to a complex combination of ponds and flocculants. The location of the plant and the amount of available space may also become factors in determining a solution to the problem.

Information on water clarification systems used in sand and gravel plants seemingly is very limited. Few plants replied to the letters and questionnaires sent out. Of those owners who did reply most indicated the use of low ground or worked out pits on their own property as holding or settling ponds. Most of the ponds or pits are large in area and volume and have no overflow. A few overflow only after heavy rains or during the spring run-off in which case the turbidity of the water is mixed with run-off water. Overflow from a few plants is discharged into storm sewers.

Companies that had installed clarification systems used parts of their excavated areas to form or build into multiple basins. Plant waste water was treated with coagulants and/or flocculants before discharging into the first or primary basin. With the aid of the coagulant and flocculants most of the suspended material settled out in this first or primary basin. Water flowed over weirs from one basin to the next. The weirs were made relatively long to decrease the depth of water over the weir and to serve as a skimmer. The clarified water in the last basin was then recycled back as plant water. This made a closed loop system and eliminated discharging water from the plant site.

Because the primary pond collects the major portion of the sediment, it requires periodic cleaning or relocation. Some companies use the primary pond as a means of restoring its worked out areas. The area is diked off and the waste water is pumped to this pond. The overflow is piped to a series of permanent basins separated by weirs and water in the last basin is used as the source of plant water. When sediment has built up in the primary pond to the desired level, the pond is relocated over the next area needing restoration.

Periodic cleaning is required in the permanent basins and that sediment is also used as landfill.

One company has installed two separate primary holding basins each having a capacity greater than a full day's supply of discharged water. Each basin receives a day's supply of water every other day, allowing one day for settling time in each basin after which the water is discharged into a third holding basin and pumped back to the plant again. Periodically each of the primary settling basins is cleaned and the sediment hauled off as waste or used as landfill material. This also becomes a closed loop system with no water being discharged from the site.

One company that discharges all of its waste water into a waterway has clarified its water from 7,000 mg/l of suspended particles to under 200 mg/l. This company uses three ponds and a polymer treatment system. Waste water flows into the first and largest pond where the coarser particles settle out. The mixed and diluted polymer is mixed into the waste water between the first and second ponds and again between the second and third ponds. This company, after experimentation, found this arrangement to be more economical and satisfactory than introducing the polymer in the flow into the first pond. Another company with a similar chain of three ponds found it necessary to use polymers and coagulants at the inlets of all three ponds.

Inasmuch as each plant varies in size and orientation of site as well as in the amount and kinds of suspended material in the waste water, determining the kind and arrangement of a water clarification system requires careful study and planning. Samples of the waste water should be analyzed both for its chemical content and for the settling rate of the suspended particles. Areas to be used for filtration ponds should be checked for absorption rate. The size of the basins or ponds is dependent upon the amount of water discharged and the settling rate of the

suspended particles. The use of coagulants and flocculants speeds up the settling rate of the suspended particles and can help to decrease the size of the ponds or basins. Samples of the waste water should be tested with combinations of these additives. The comparison of settling rates with costs of the additives will determine which combination should be used.

SECTION V

AGGREGATE PLANT SETTLING PONDS

Settling ponds are generally used where there is sufficient low ground or worked out areas available to form such ponds. The sediment will fill the pond areas and restore the land. Settling ponds are ponds that allow solids to settle and the clarified water overflows. Those ponds that will allow seepage are referred to as filter ponds and will be discussed in the next section. Most settling ponds are also filter ponds but are separated in this report for clarity.

Settling ponds have limited efficiency, especially in deposits with clay or light fines that do not settle quickly by the natural process. Yet, because this system takes very little effort on the part of the operator and because abandoned pits are frequently available, it is widely used. Proper planning and sizing of ponds result in an effecient and economical system. Water will rarely clear up enough to be discharged into waterways, but it normally will be clear enough for washing the aggregate in a recycling operation.

Correspondence from many plant operators discussed effectiveness of settling ponds. A number of plants were visited during the course of the study. Figures 1, 2, 3, 4 and 5 show settlement rates for various particle sizes and specific gravities at maximum horizontal movement. Often settlement rates are found to be much slower than Stokes law would suggest, probably due to varying negative charge of the suspended particles. The operator must decide what size particles can be permitted in the recycled water without damaging equipment and still achieve the necessary washing effect. The specific gravity must also be known and can be determined by using a hydrometer giving direct specific gravity reading.

The specific gravity of a body is defined as the ratio of its weight to an equal volume of water. The specific gravity of effluent water from an aggregate plant runs from 1.000 to 1.060. The weight of the dry sediment can be determined by evaporating the water from a sample of effluent and weighing the dry sample and measuring its volume. (See Figure 8 and example later in report.)

Settling pond sizes can be determined from Figures 1 through 9.

It has been found that ponds will short circuit, that is, form a stream from inlet to outlet, causing great increases in horizontal velocities and a reduction in settlement. Turbulance, sediment and buildup variations in specific gravity can greatly reduce the settling pond efficiency.

A second pond is required to skim off the cleanest water with a weir. The second pond is normally the same size as the primary pond to allow for additional settling, thus it can be used as a future primary pond. The water must run from the pumping pond back to the plant. If clearer water is desired, coagulants can be added just ahead of the secondary ponds. (See section on coagulants for more information.)

Several factors must be included in a well-designed settling pond.

1. Water velocities must remain low, including inlet and outlet.

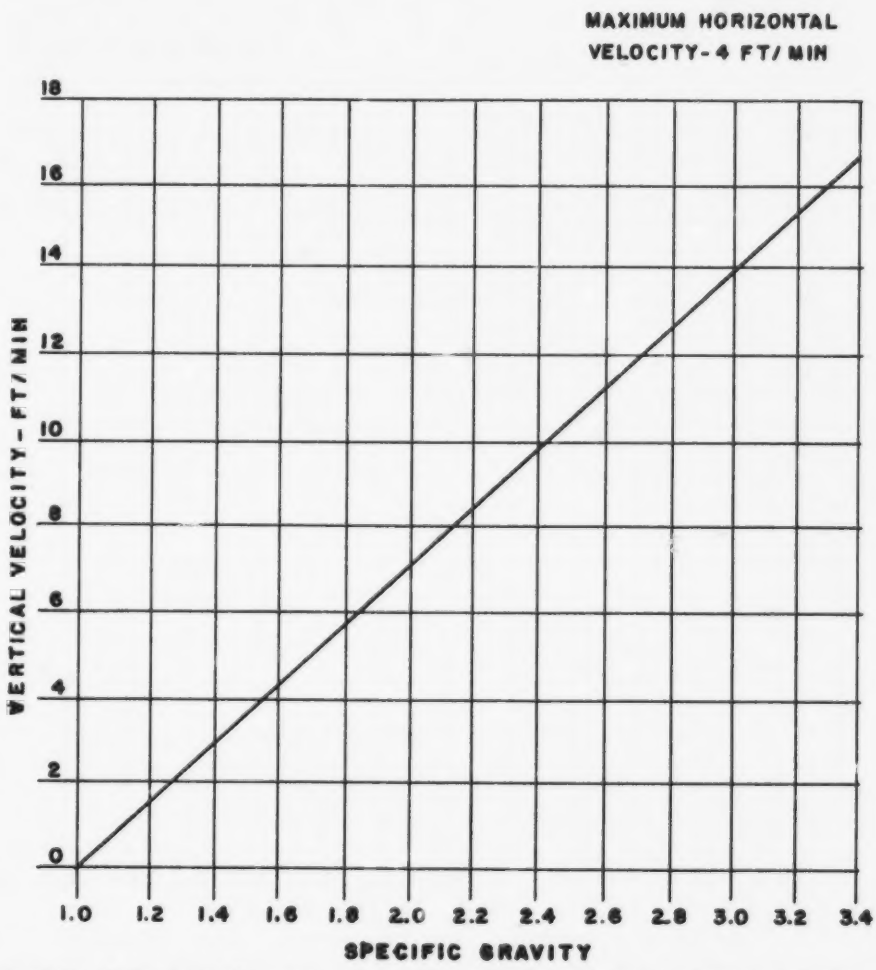
2. Inlet water must be introduced into the pond across the full width to avoid short circuiting and to get full pond usage. This is accomplished by piping into the pond in several places across the width.

3. Outlet water must flow out slowly to avoid scouring, that is, picking up the particles that are supposedly being removed. This can be done by maintaining a minimum outlet of one foot of width for every 25 GPM of water being used. This has not been the practice in most plants, but would be necessary to maintain pond efficiency. The depth of outlet water can be controlled by the use of gates for regulating the secondary pond level.

Before an operator makes a decision to adopt this system a sample of water should be tested to determine the length of time required to become sufficiently clear to permit recycling to the plant as wash water. If settling time is too lengthy, a small amount of coagulant could be used to neutralize the particles and aid in settling. (See section on coagulants.)

To explain the figures, a hypothetical plant will be used as an example.

Known--plant water use--2,500 GPM.
Known--jar test shows water would be clear enough for rewashing after it has settled for a minimum of 48 hours.



DEVELOPED FROM STOKE'S LAW AND FROM CHARTS IN THE NATIONAL READY MIXED CONCRETE ASSN. PUBLICATION NUMBER 116.

FIGURE NO. 1 SETTLEMENT RATES OF .01 INCH PARTICLES

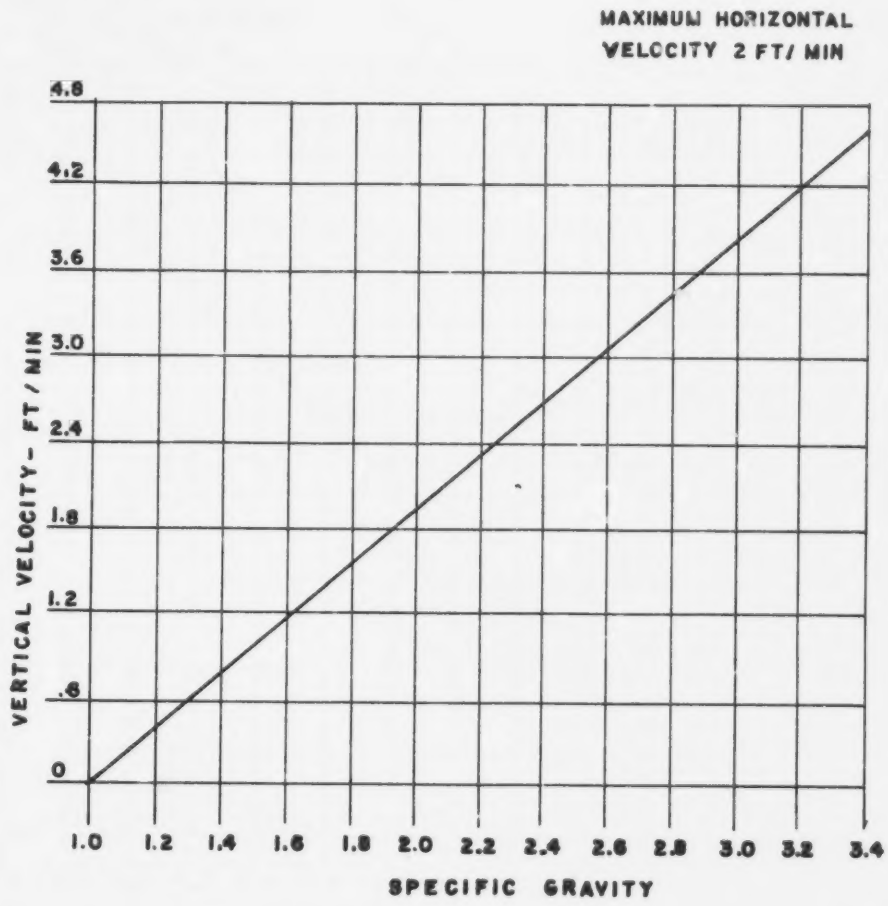


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FIGURE NO. 2 SETTLEMENT RATES OF .005 INCH PARTICLES

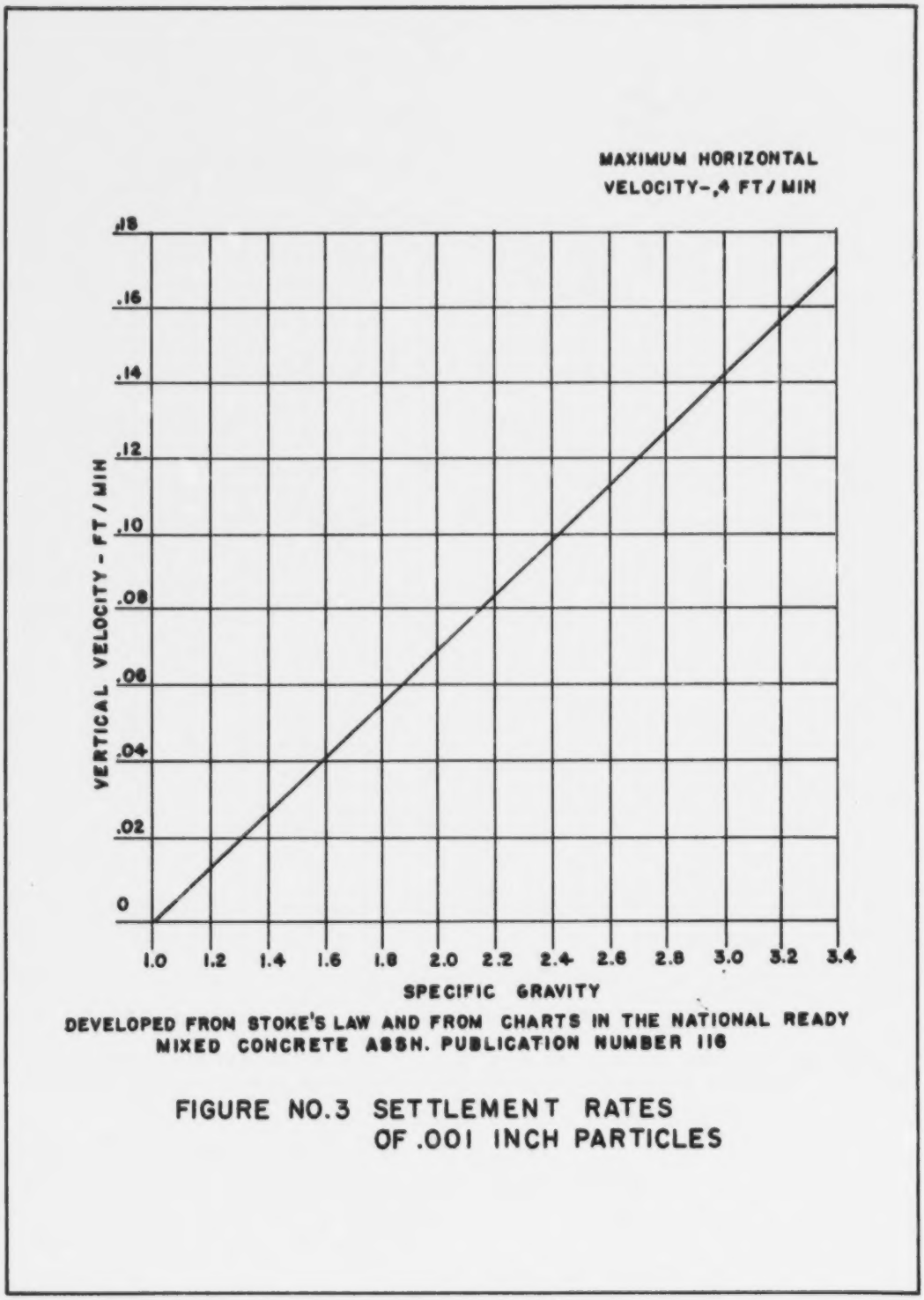

FIGURE NO.3 SETTLEMENT RATES
OF .001 INCH PARTICLES

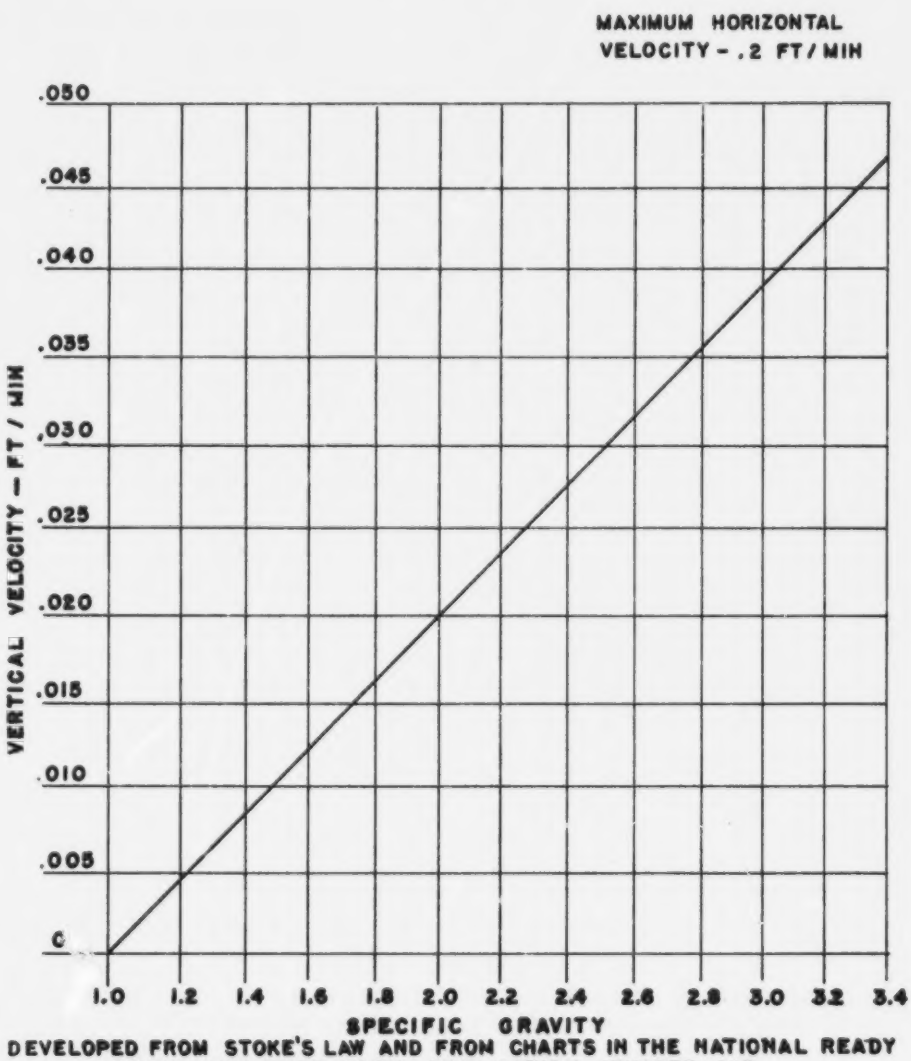

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FIGURE NO. 4 SETTLEMENT RATES OF .0005 INCH PARTICLES

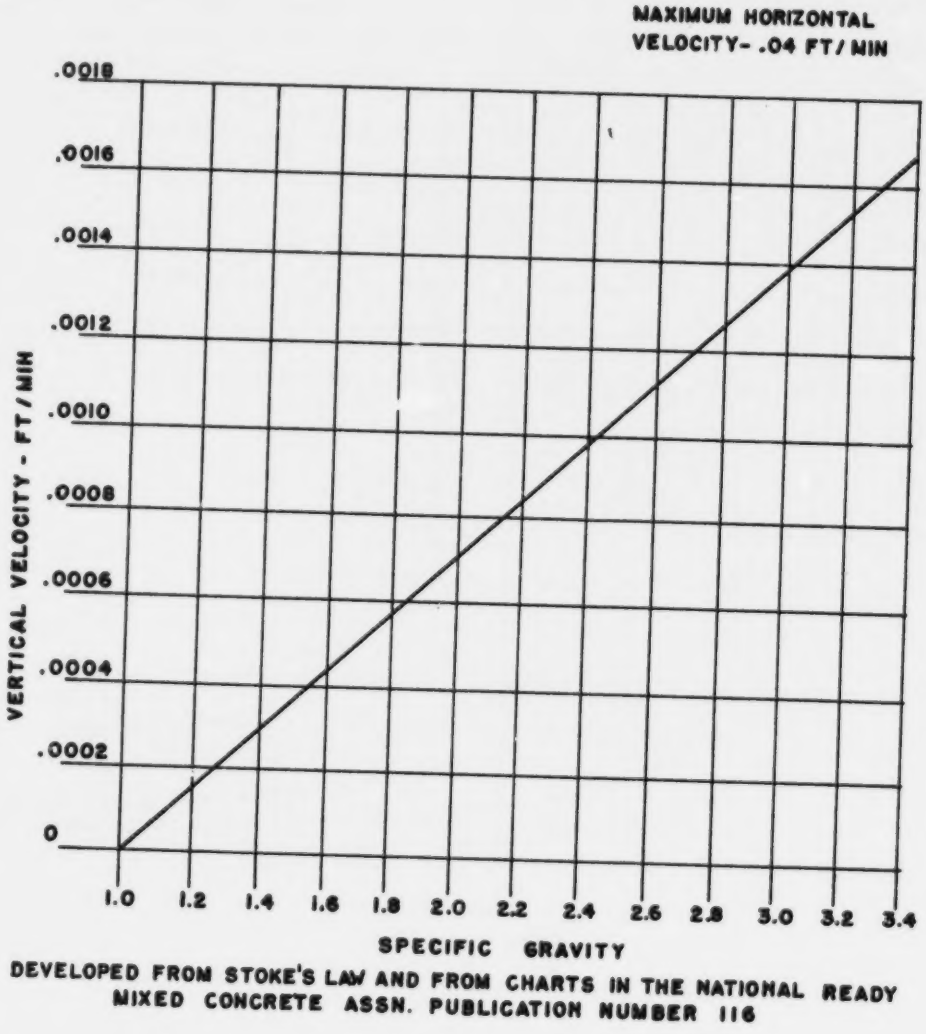

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FIGURE NO.5 SETTLEMENT RATES OF .0001 INCH PARTICLES

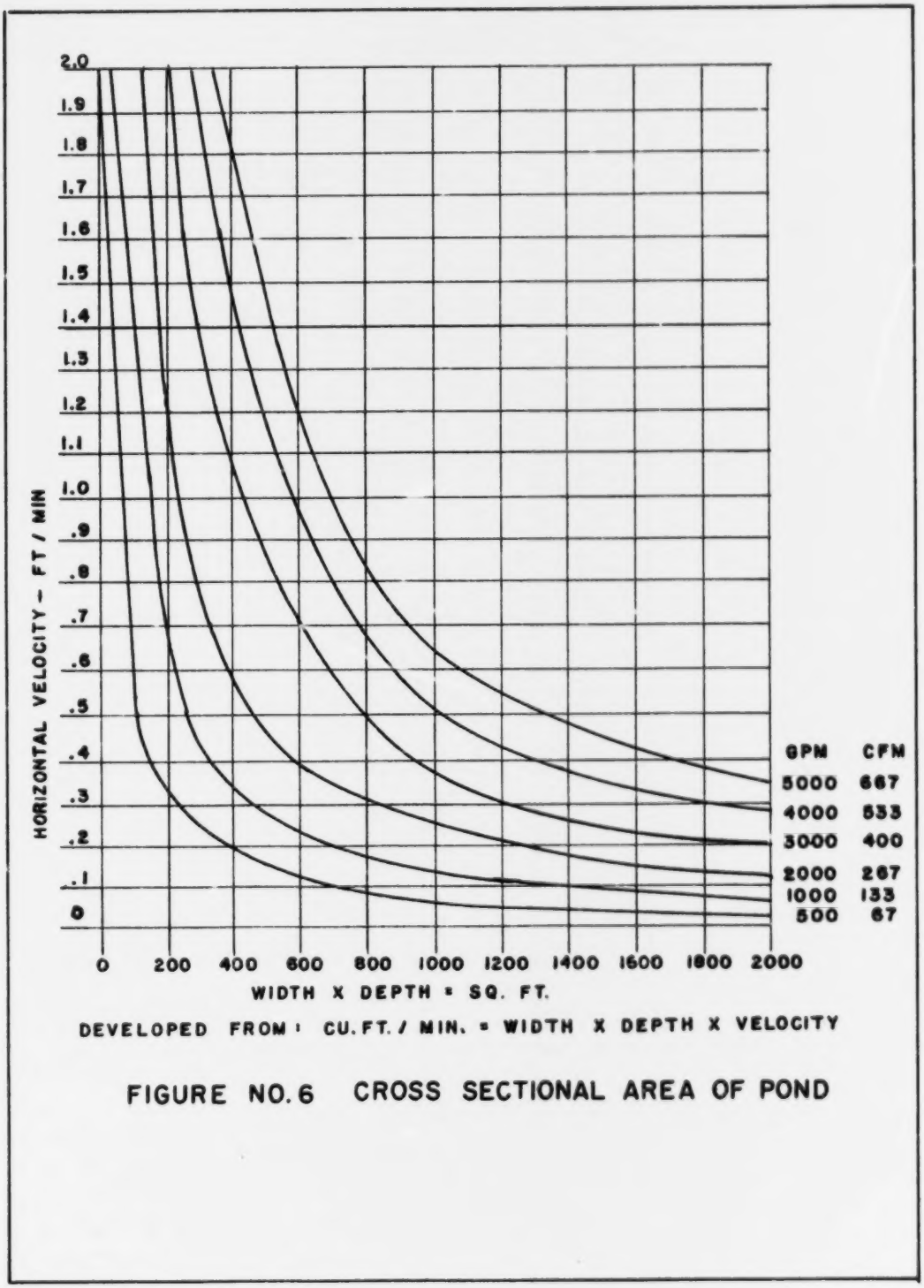
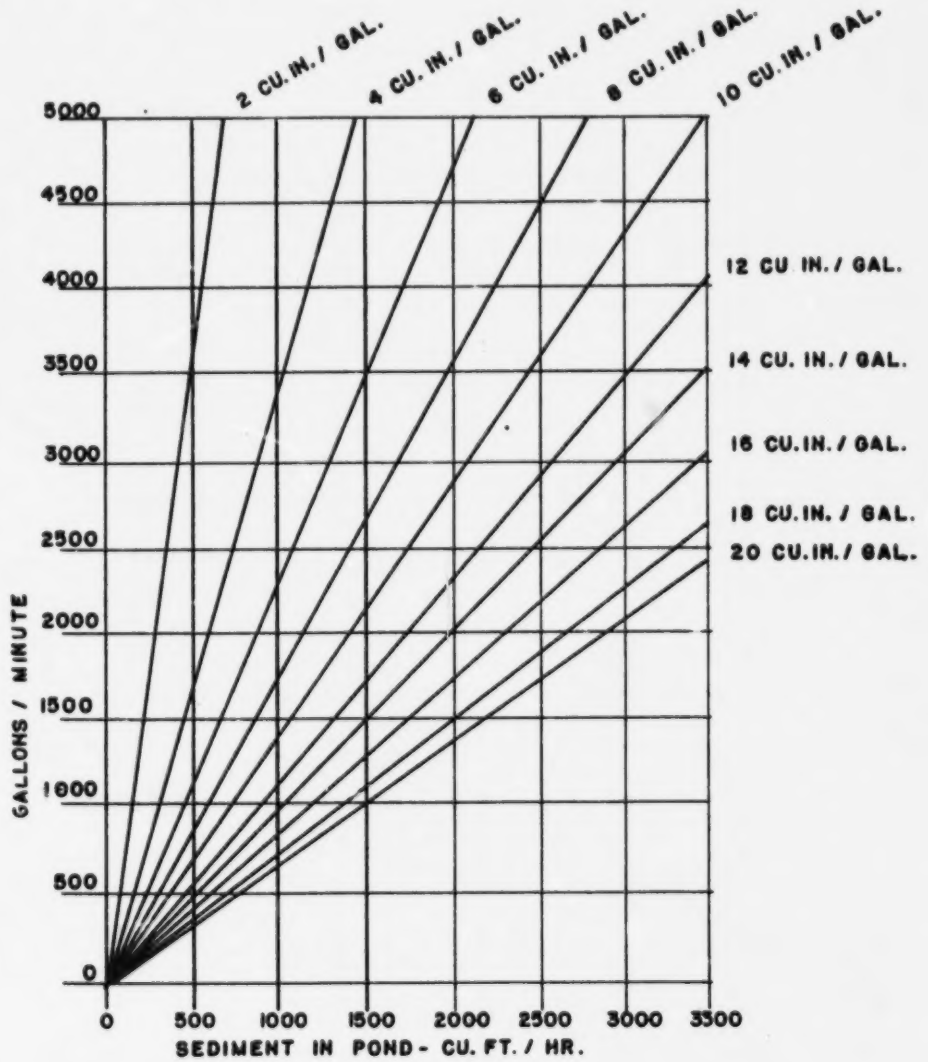
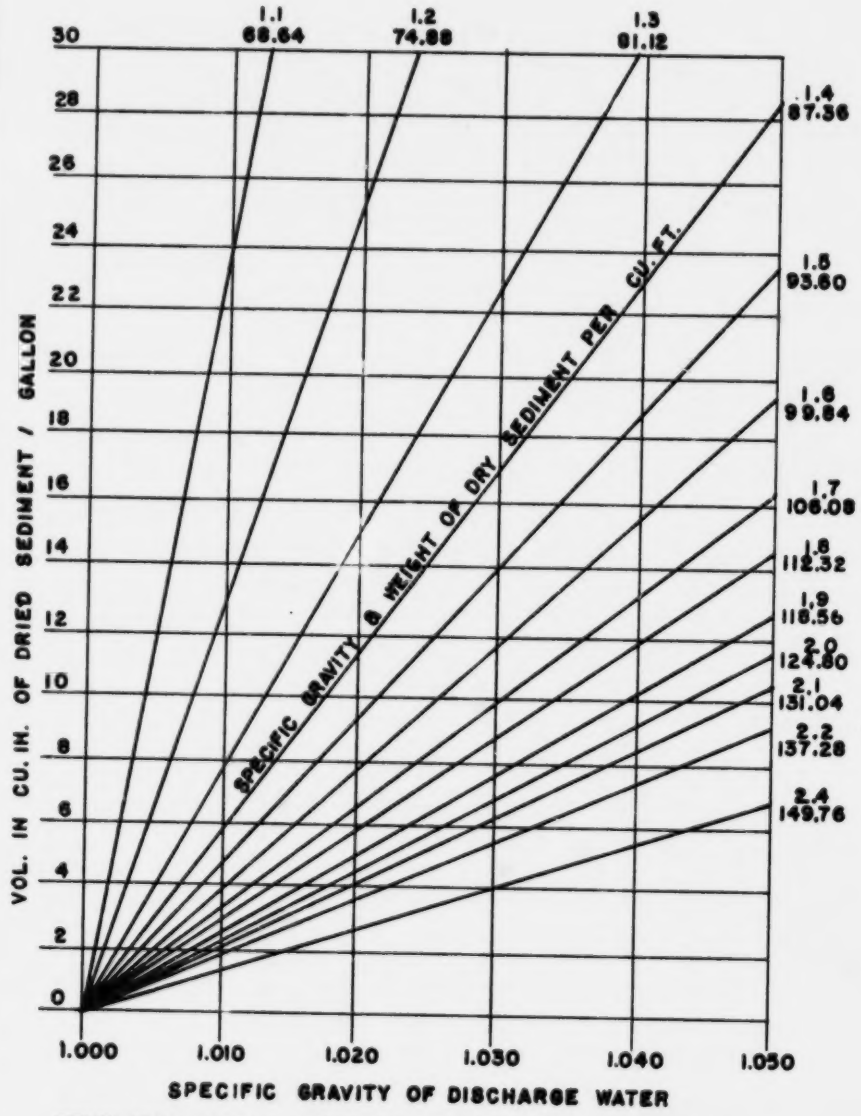


FIGURE NO. 6 CROSS SECTIONAL AREA OF POND



DEVELOPED FROM JAR TEST RATIO OF VOL. SEDIMENT / GAL. WATER X TOTAL GAL. OF WATER / HR. = TOTAL VOL. SEDIMENT / HR.

FIGURE NO. 7 VOL. OF SEDIMENT BUILDUP IN SETTLING PONDS



DEVELOPED FROM : VOL. OF MIXTURE X S.G. OF MIXTURE = VOL. OF SEDIMENT X S.G. OF SEDIMENT + (VOL. OF MIXTURE - VOL. OF SEDIMENT) X S.G. OF WATER

FIGURE NO.8 WEIGHT OF DRIED SEDIMENT

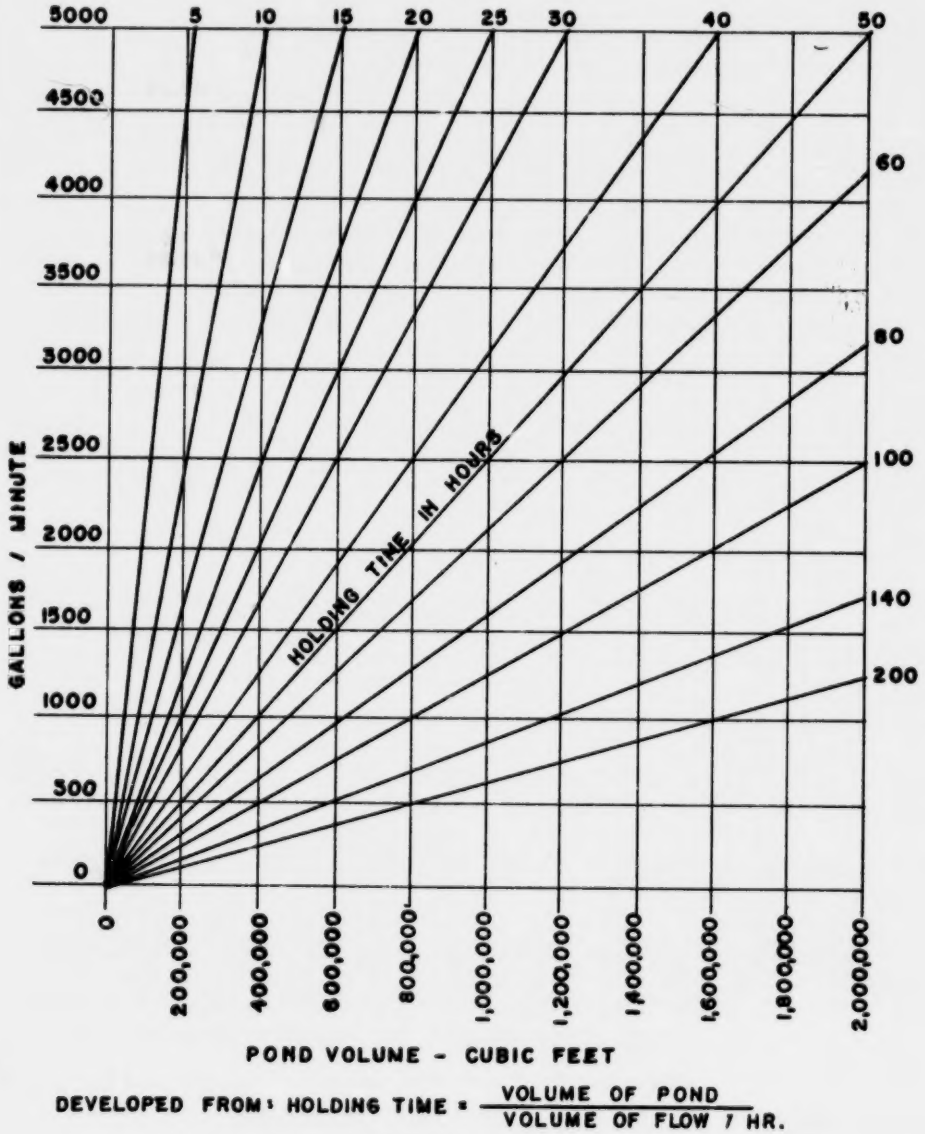


FIGURE NO. 9 POND HOLDING TIME

Known--maximum particle size acceptable in recycle water--0.0005 inch.

Determine discharge water specific gravity by using a hydrometer--hydrometer reading--1.018.

The specific gravity of the suspended solids can be determined by measuring one gallon of waste water and evaporating the water. To speed this process it is possible to mix some coagulants such as alum in the sample so the suspended solids will settle out. The excess clear water can be drained off and then the wet sediment placed in an oven where the remaining moisture will evaporate off. The dry sediment must be measured accurately in cubic inches.

Dried sediment volume = 10.2 cu in./gal.

With this information Figure 8 shows the specific gravity and weight of the dried sediment for 10.2 cu in./gal. and 1.018 specific gravity.

Figure 8 dried sediment = 1.40 or 87.36 PCF.

Figure 4 shows the settling rates of .0005 inch particles with a specific gravity of 1.4 and a horizontal velocity of 0.2 feet per minute.

Figure 4 settling velocity = 0.008 ft/min.

Figure 6 gives the pond cross section or width times depth for 2,500 GPM and 0.2 feet per minute horizontal velocity.

Figure 6 width x depth = 1,600 sq ft or 200 ft wide and 8 ft deep.

When this much cross sectional area is needed, care must be taken to avoid short circuiting. If the pond is to be cleaned, it must be narrow enough for equipment to reach half way across. Pond length can be determined by the following formula:

$$\text{Length} = \text{width} + \frac{\text{horizontal velocity x depth}}{\text{vertical velocity}}$$

$$\text{Length} = 200 + \frac{.2 \times 8}{.008} = 400 \text{ feet}$$

The water must flow over a long weir from the pond to the pumping pond. The weir should be a minimum of one foot wide for each 25 GPM. The pumping pond can be just large enough for surge water or, if the land is being rehabilitated,

it is best to have the pumping pond the same size as the primary pond. This will allow the pumping pond to become the primary pond as soon as the existing primary pond is filled. The holding time of the pond may be checked from Figure 9. The ponds selected are two 200' x 8' x 400' ponds.

Volume = 2 x 200 x 8 x 400 = 1,280,000 cu ft.

Figure 9 holding time = 60 hours.

It was noted as known information from timing a jar sample that 48 hours was required to get satisfactory clarification. This has been achieved by having pumping ponds the same size as the primary pond.

Thus far the minimum pond depth has been discussed, but provisions must be made for sediment. It was determined earlier that there is a volume of 10.2 cubic inches per gallon of dried sediment, which is above normal. The wet sediment such as would be found in the pond bottom will average about two times the bulk of the dry sample. Figure 7 shows the buildup in cubic feet.

Figure 7 sediment buildup = 1,800 CF/hr.

Almost all the sediment volume will settle in the primary pond. One pond has a bottom area of 200' x 400' = 80,000 square feet. The assumption is that the plant operates 200 hours per month.

$$\text{Sediment buildup} = \frac{1{,}800 \text{ CF/hr} \times 200 \text{ hr/mo}}{80{,}000 \text{ sq ft}} = 4.5 \text{ ft/mo.}$$

The ponds could be two 200' x 25' x 400' and this would allow approximately four months' filling time. As the ponds filled, the additional ponds could be built. The figures used in this example were taken from an operating plant that has much higher than normal amount of suspended solids.

It is important to make the jar test to determine the time required to obtain adequate settling. In this example the buildup of sediment becomes the main problem. The size of the pond must be determined by available land. If land is not available a much smaller pond can be used with almost continual dredging and hauling away. The operator must now decide which of his original decisions should be altered.

The most important considerations in settling pond design are:

1. Cross sectional area of pond must be large so horizontal velocity is very slow.

2. Water must enter pond over most of the width to make the entire pond effective.

3. Outlet must be wide to skim off top cleanest water and to keep horizontal velocity low.

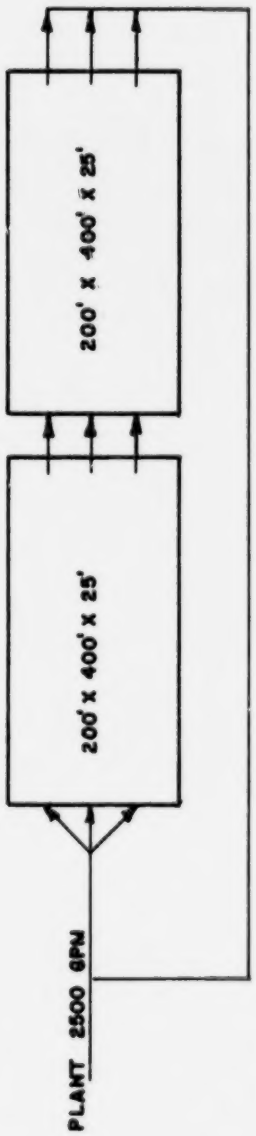


FIGURE NO. 10 PLANT LAYOUT

Notice narrow weir and large water drop causes high horizontal velocities. Fines cannot settle out.

FIGURE 11 SETTLING POND WEIR

Narrow fast-dropping stream does not allow fines to settle. This was the most frequently observed problem. Water must have very low horizontal velocities.

FIGURE 12 SETTLING POND SHORT CIRCUIT

This pond is wide and deep allowing low horizontal velocities and good settlement.

FIGURE 13 EFFECTIVE SETTLING POND

Combination settling ponds and land rehabilitation. Note land rehabilitation on right is capable of growing good ground cover.

FIGURE 14 SETTLING POND LAND REHABILITATION

SECTION VI

AGGREGATE PLANT FILTER PONDS

Filter ponds are those systems which allow the plant discharge water to flow into a pond that has no outlet or complete recirculation. The water seeps out the bottom and side of the pond and is clarified by this filtering process. Many factors affect the success of such a system, so they must be considered.

1. The water table must be low enough that the water will filter out, not into, the pond at any time the plant is running.

2. The walls and bottom of the pond must be porous through which to allow the water to flow.

3. The pond must be large enough so it will not seal too rapidly.

4. There must be enough water used so the suspended particles will not seal the bottom and sides too quickly.

Most of the plants which use this system have used old mined out pits or natural canyons for filter ponds. This means the pond was not designed for minimum size, but rather the land that was available was used. However, if the size and depth of these ponds can be determined, the bottom and side areas required to achieve equilibrium will be known. Examples of typical plant layouts are cited below.

The plant in Figure 15, discharging 200 GPM into a 50 feet by 150 feet by 4 feet primary pond over a weir and into a 80 feet by 1,800 feet by 4 feet filter pond, has operated for seven years without any signs of the pond sides or bottom sealing. The soil has heavy vegetation and on first appearance, would not seem to be porous enough to allow sufficient seepage. However, by inspecting the dredgings from the primary pond, which must be cleaned every two weeks, it was noted that the settled material is mostly granular. Most of the fines in the natural deposit are granular, thus porous. The filter pond wall and bottom surface total about 150,000 square feet and provides an area of 750 square feet for each gallon per minute of inflow. The pond is at equilibrium at this point, giving an idea of the area required for filtering in this type of soil.

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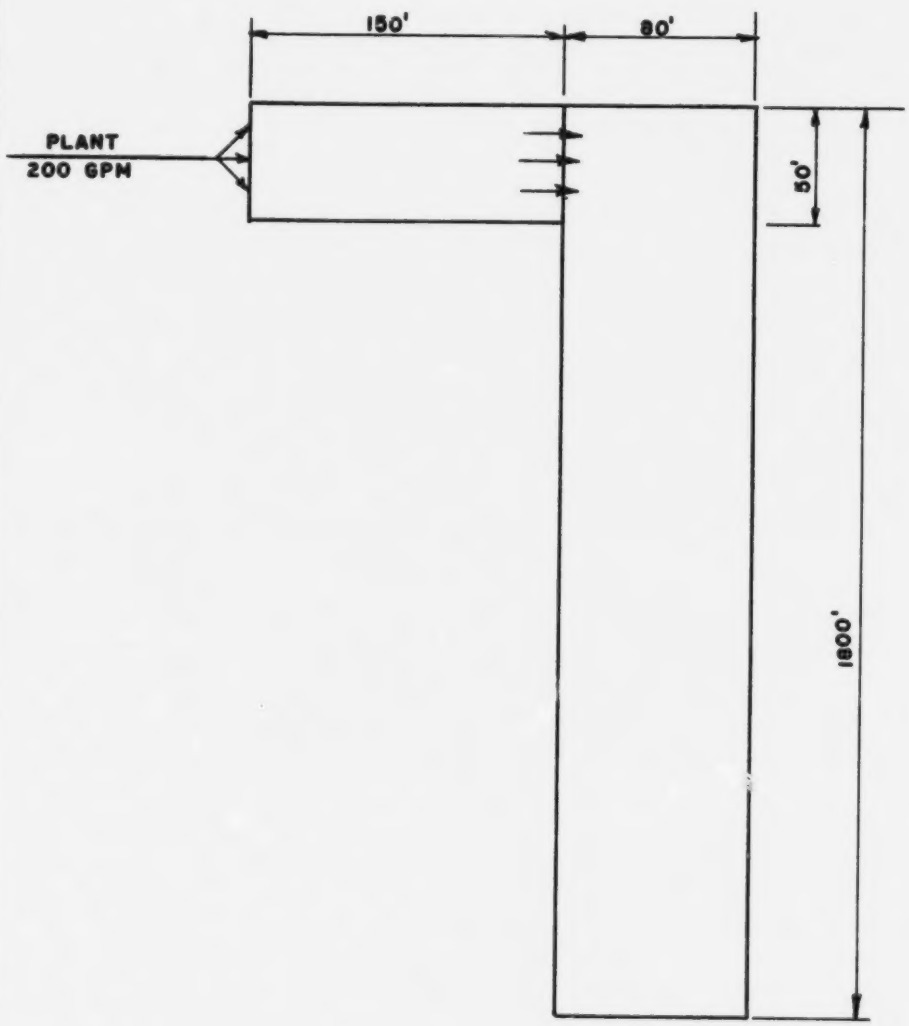


FIGURE NO. 15 PLANT LAYOUT

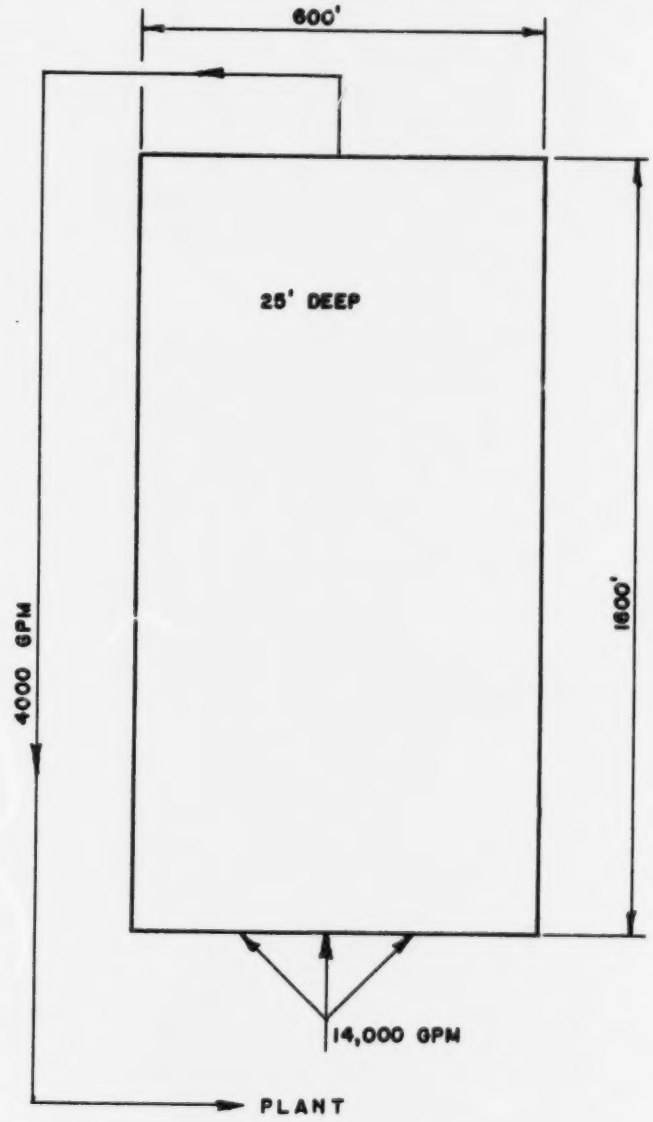


FIGURE NO. 16 PLANT LAYOUT

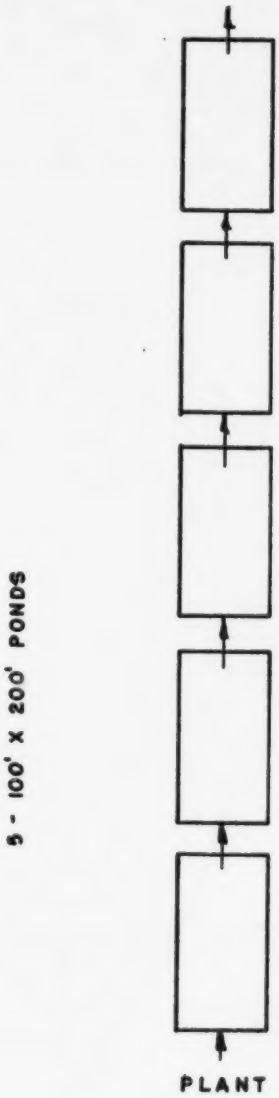


FIGURE NO. 17 PLANT LAYOUT

The plant in Figure 16 discharges 14,000 GPM and recycles 4,000 GPM, so 10,000 GPM filters out in a 1,600 feet by 600 feet by 25 feet pond. Although the sediment will gradually fill and seal part of the pond, there is ample pond size to avoid sealing of the entire wall and bottom surfaces of pond. The raw material has very little clay and only 1% minus 50 mesh and only 0.2% minus 200 mesh. The surface area of the bottom and walls is about one million square feet or 100 square feet per GPM. It must be kept in mind that this plant has little clay or fines, resulting in ideal filtering with little or no sealing.

The plant in Figure 17 discharges 300 GPM and recycles 150 GPM, so 150 GPM filters out in a series of five 100 feet by 200 feet by 4 feet ponds. The first pond is a primary settling pond, which becomes sealed, and the remaining four are filter ponds. Approximate area of the walls and bottoms of the four filter ponds is 80,000 square feet which provides 533 square feet of area per GPM.

The plant in Figure 18 discharges 150 GPM with no recycle. The pond is 60 feet by 120 feet by 5 feet. The material making up the pond bottom is sand and silt and the wash water is also sand and silt with very little clay. The water table is well below the pond and an open pit exists next to the pond, which may allow the water to seep away more rapidly. This provides 67 square feet per GPM.

The plant in Figure 19 discharges 2,000 GPM with no recycle. The entire amount flows into a 300 feet by 300 feet by 10 feet pond and filters into the ground. The ground water is well below the pond bottom at all times of the year. The pond bottom is sand and gravel and the discharge water carries about 2% sand and very little clay. The pond is seldom cleaned and has not sealed. It has a filter area of 50 square feet per GPM.

The plant in Figure 20 discharges 500 GPM with no recirculation from the pond. However, the water washes the aggregate five times during the process before being discharged. The discharged water carries about 2% silt and clay. The suspended solids and dissolved solids are being used effectively for land rehabilitation. Discharge runs through concrete pipe to a 200 feet by 500 feet area to be built up. Water runs off this area into a 400 feet by 500 feet pond. The overflow then goes into a 400 feet by 200 feet pond. The water table varies due to irrigation and precipitation. Sometimes the pond has water seeping

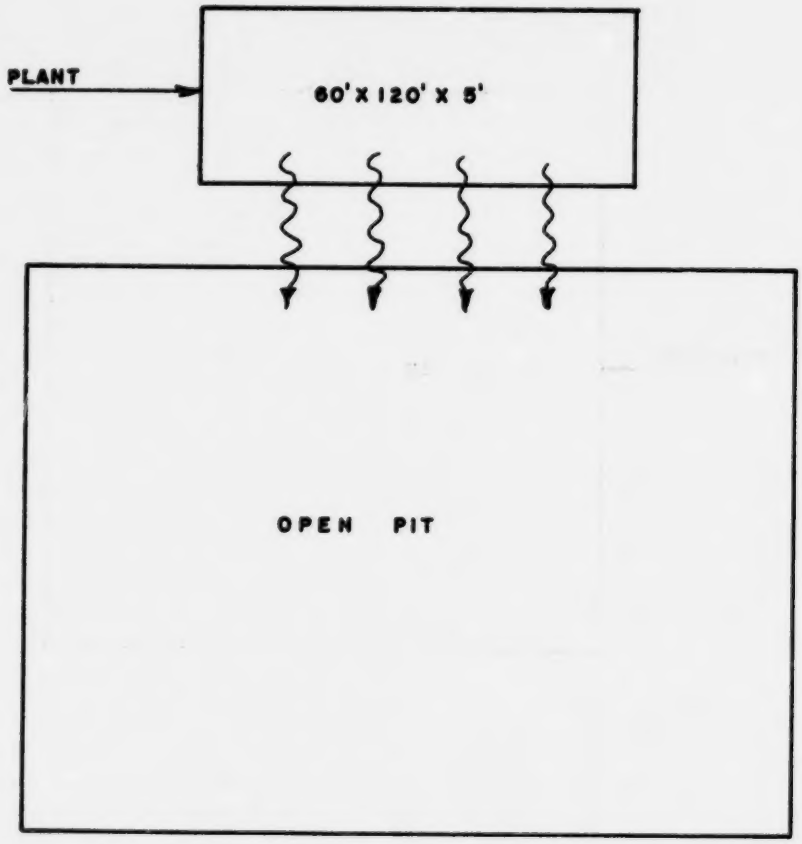


FIGURE NO. 18 PLANT LAYOUT

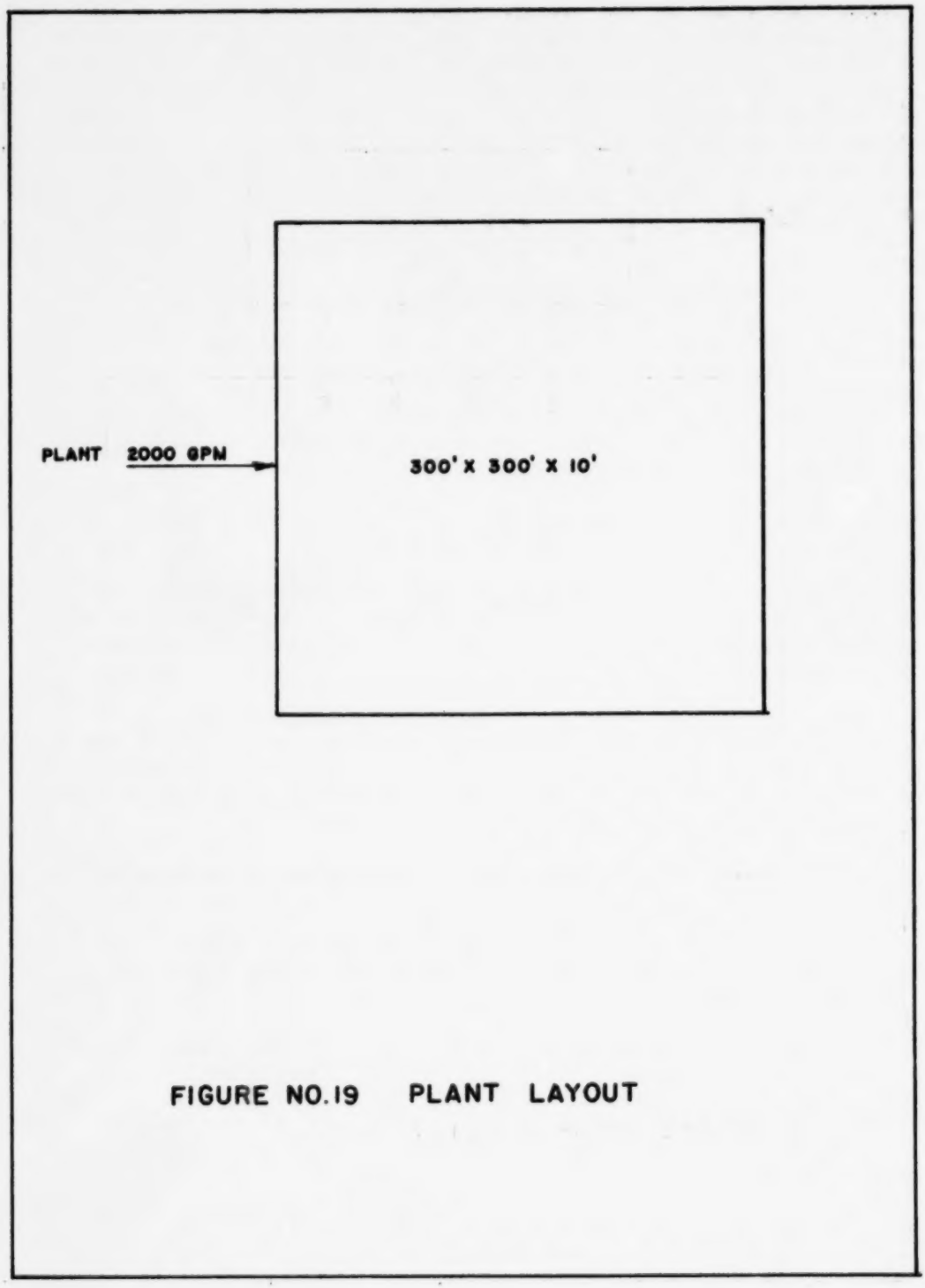


FIGURE NO.19 PLANT LAYOUT

in and other times the ponds dry up. During dry weather both ponds go dry. At that time the filtering takes place in the 200 feet by 500 feet buildup area, where 200 square feet per GPM are required. During wet seasons and when the irrigation canal is high there is an inflow of surface water and canal water, and the ponds rise above the canal and water table. The 200 square feet per GPM is still approximately correct, but this does emphasize the necessity of knowing ground water conditions for all times of the year.

The plant in Figure 21 discharges 2,500 GPM into a series of three ponds. Seven hundred GPM overflow into a waterway and the rest filters into the sides and bottom of the filter ponds with 16 PPM suspended solids and Jackson Turbidity unit readings of 13-36. Over two per cent of the fines are smaller than 200 mesh with some silts and clays. The series of three ponds total 650,000 square feet. This plant has 360 square feet per GPM.

From these examples, areas to take into consideration in designing filter ponds can be established.

1. Water table must be low enough all year to allow water to flow out during operation and rains. Pond berms must be high enough to guard against flood conditions carrying out turbid water.

2. Pond walls and bottom areas must be inspected to determine the porosity of the soil. The waste water solids should also be evaluated as light or heavy concentration of sand, silt or clay. The examples given show the wide variation of results caused by porosity.

3. It is best to use two ponds. The primary pond is used for heavy particle settlement, so the filter bed will not fill with solids too fast. The weir from the primary pond to the secondary pond should be as wide as possible to reduce the velocity of water. This skims the cleanest water off the top and minimizes short circuiting.

4. Filter pond walls are more efficient than the bottom, so deep steep walled filter ponds are desirable. Ponds will seal more slowly if they are kept full so all the area of walls and bottom can be working. Allowing the pond to rest every couple of months also improves its filter life.

5. The use of flocculants will shorten the filter pond life, therefore their use should be restricted to the primary

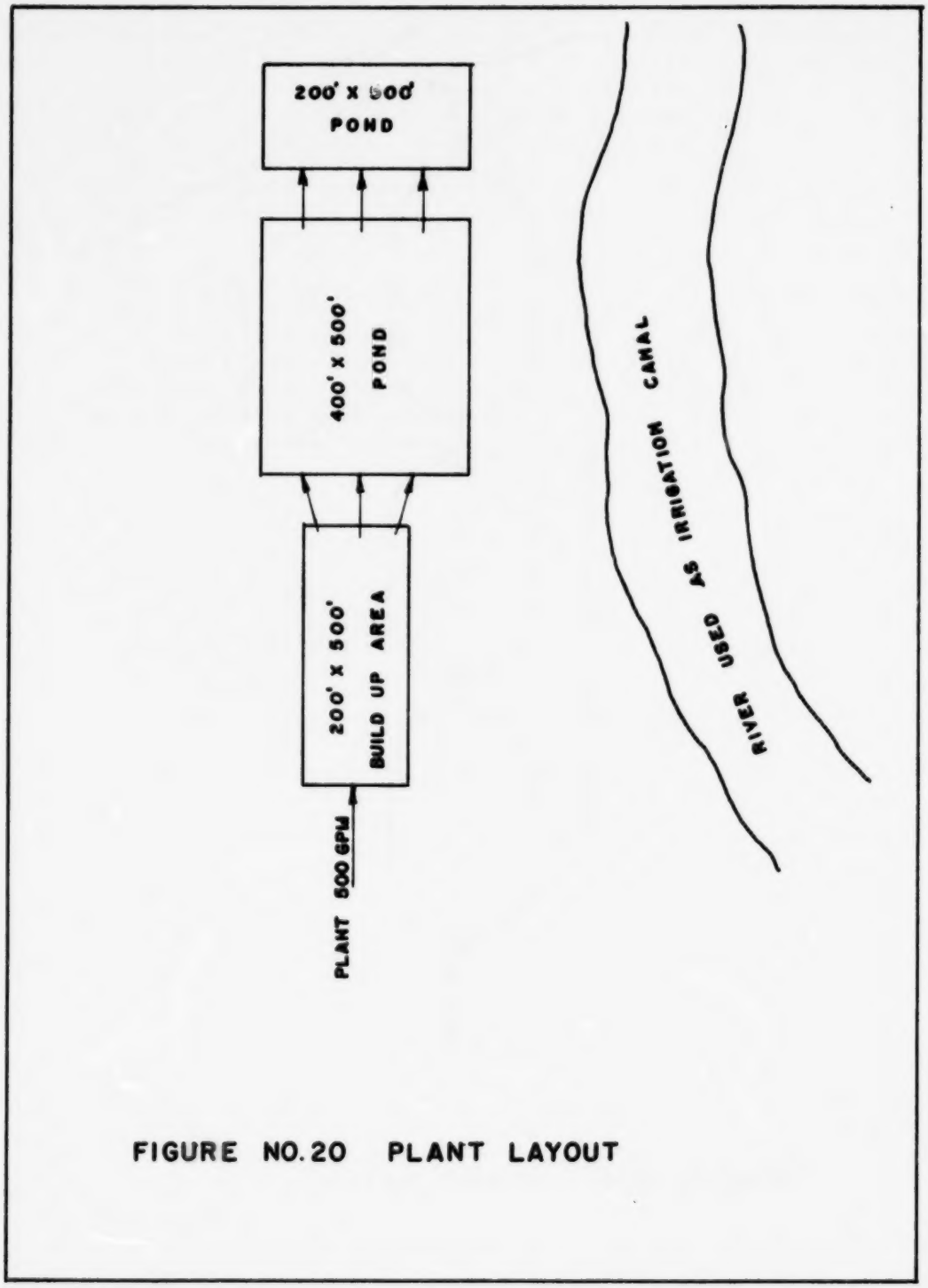


FIGURE NO. 20 PLANT LAYOUT

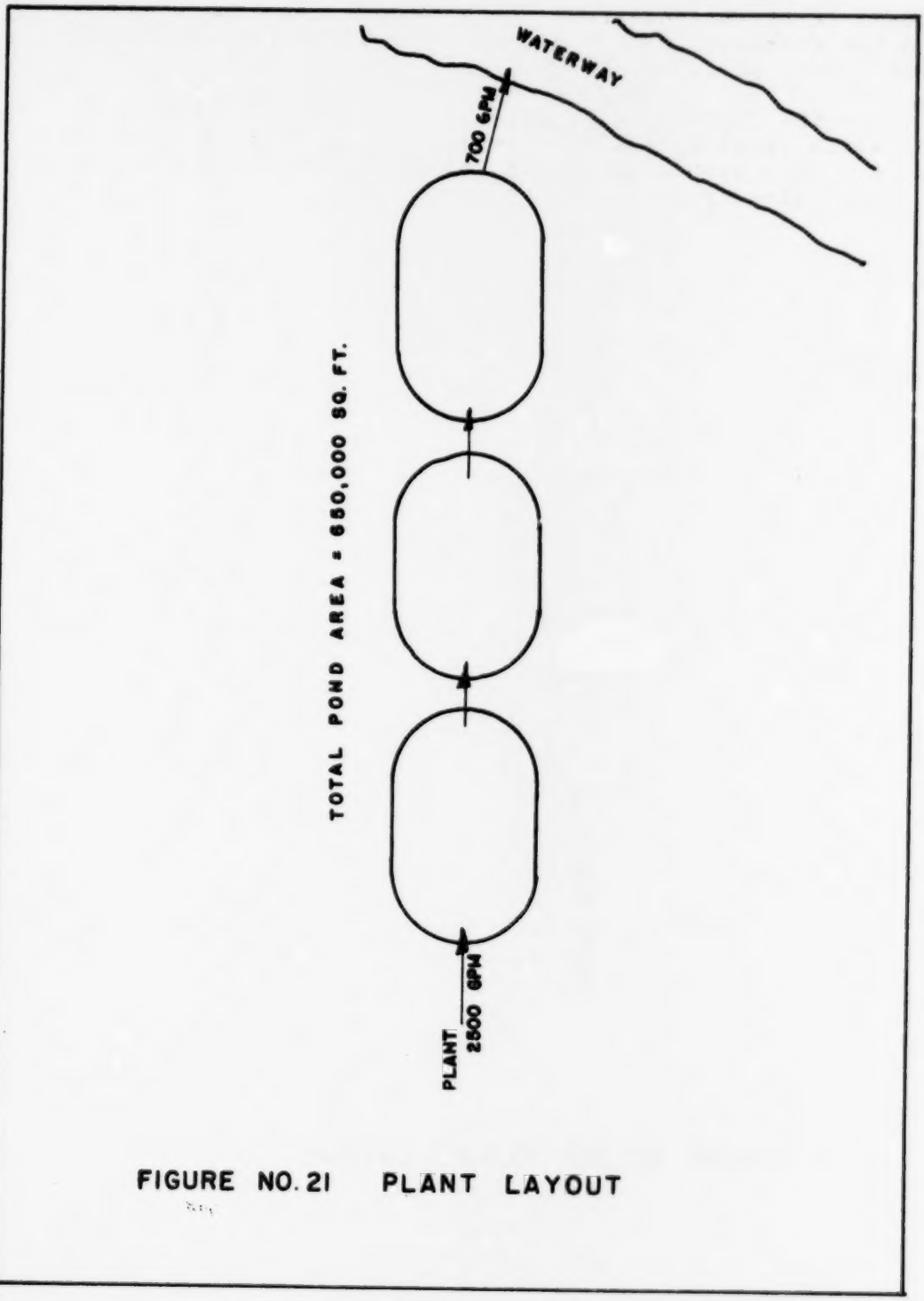


FIGURE NO. 21 PLANT LAYOUT

pond; or three ponds could be used and flocculants added in the secondary pond. Flocculants should not be used in the filter pond.

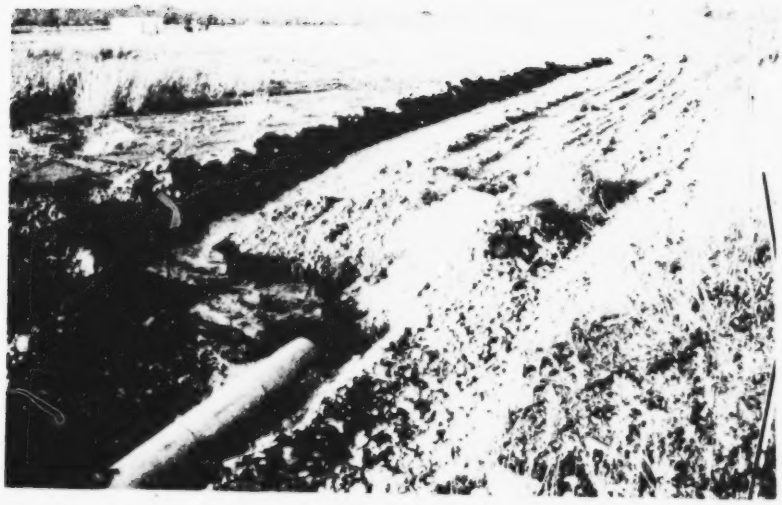
6. If the filter bed is above the water table, lowlands or wells close by could be endangered by seepage from the pond. This should be considered in the location and design of the filter pond.

TABLE 2

APPROXIMATE FILTER POND SIZE

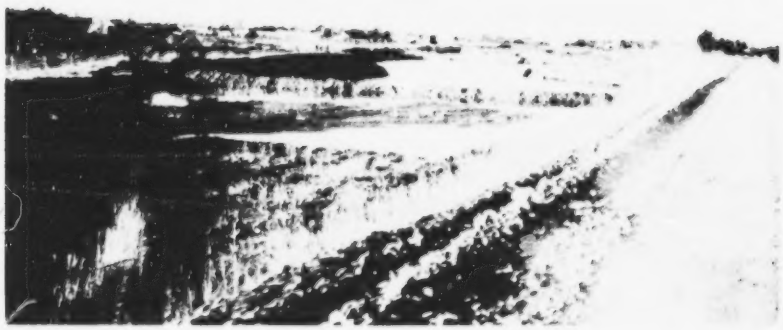
Filter Pond Area/GPM	Classification of Pond Walls and Bottom	Classification Plant Discharge Water
50 sq ft	Coarse Aggregate	Sandy sediment
100	"	Sand and clay
150	"	Clay
200	Aggregate and Sand	Sandy sediment
250	"	Sand and clay
300	"	Clay
350	Aggregate, sand, silt and clay	Sandy sediment
400	"	Sand and clay
450	"	Clay
700	Sand, silt and clay	Sandy sediment
750	"	Sand and clay
800	"	Clay
Not recommended	Clay	Sandy sediment
"	"	Sand and clay
"	"	Clay

Developed from information provided by field inspections of existing filter ponds.



Method of transporting water. Where no settling is desired, water may be fast running in pipe or narrow ditch. Note: Land where ditch is located has been rehabilitated by allowing the water to run slowly over entire area.

FIGURE 22 FILTER PONDS WATER CONTROL



Combination filter pond and land rehabilitation. Rehabilitated land on left. Filter pond in background. Berm on right which allows water to filter through to waterway.

FIGURE 23 FILTER PONDS ARRANGEMENT

SECTION VII

AGGREGATE PLANT COAGULATION

Many aggregate plants are using coagulants as the answer to their water clarification problem. Some of the reasons for choosing coagulants are:

1. High concentration of solids that won't settle.

2. Water too dirty to reuse or discharge into waterways.

3. Limited land area for settling ponds.

4. The need to rehabilitate land quickly by settling all the solids in very small ponding areas.

Water clarification for the aggregate industry is primarily removing solids and reducing turbidity. The reason for this clarification is often to meet water quality standards set up by governmental bodies. However, clarification is often justified to reduce amount of new water needed and to reduce the wear on equipment caused by dirty water.

Turbidity is the color or lack of clearness in water. The turbidity is essentially a suspension of colloidal clay particles which generally possess negative charges. The negatively charged particles repel each other, hindering agglomeration and settlement.

Coagulants are positively charged and when mixed with the water, neutralize the negatively charged colloidal clay. This process allows the particles to floc together, causing the particles to have less surface exposed to the water, allowing in turn, faster settlement. Often it is desirable to use coagulant aids or another chemical to increase settlement rates. The aid mechanically ties the floc particles together, making bigger and heavier flocs for faster settlement.

Coagulants work better in warmer water. Settlement rate is approximately doubled for every 18° F increase in temperature.

Coagulants must be thoroughly mixed to be efficient. After a thorough mixing, a period of slow mixing is desired, as this causes the solids to pass close to other solids on

which the floccing process depends. The water then must move as slowly as possible to allow maximum settling rates.

The cost of water clarification varies widely with the material and degree of clarification needed. In most cases the cost of chemicals to clean the water sufficiently for discharge into waterways would be $0.03 to $0.06 per ton of saleable aggregate. Normally, if the water is recycled in the plant the cost is $0.02 to $0.04 per ton.

There are a number of different arrangements which are used for ponds, but the multi-pond concept seems to be the most suitable.

The chemicals offering the best economy vary with the condition of waste water. The most frequently used method of determining which coagulant should be used is the jar test. It consists of placing a measured amount of the waste water in a jar, mixing in a specific amount of the coagulant, and timing the rate of settlement. By using varying measured amounts of the various coagulants and comparing the settlement rates, the coagulants most applicable and the quantities per given volume of waste water can be determined. Some of the coagulants frequently used are:

Aluminum sulphate
$(AL_2 (SO_4)_8 18H_2O)$ alum

Ferrous sulphate
$(FeSO_4\ 7H_2O)$ copperas

Calcium hydroxide
$(Ca(OH)_2)$ hydrated lime

Calcium oxide
(CaO) quicklime

Sodium aluminate
$(Na_2Al_2O_4)$

Sodium carbonate
(Na_2CO_3) soda ash

Ferric chloride
$(FeCl_3)$ ferrisul
Acid, so could be used on alkaline condition (pH over 7)

Sodium silicate
$(Na_2SiO_3Na_2O + SiO_2)$
Alkaline, so could be used on acid condition (pH below 7)

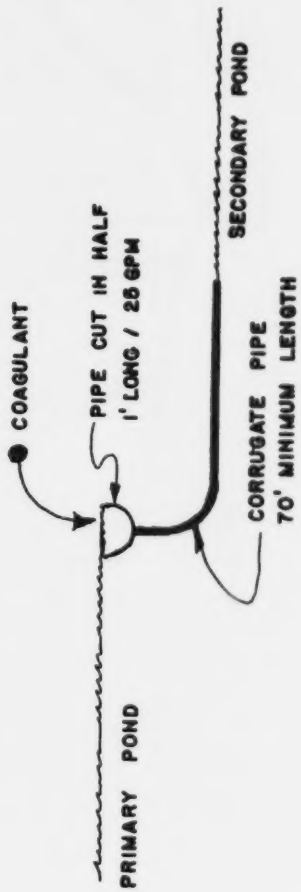


FIGURE NO. 24 WEIR & COAGULANT MIX POINT

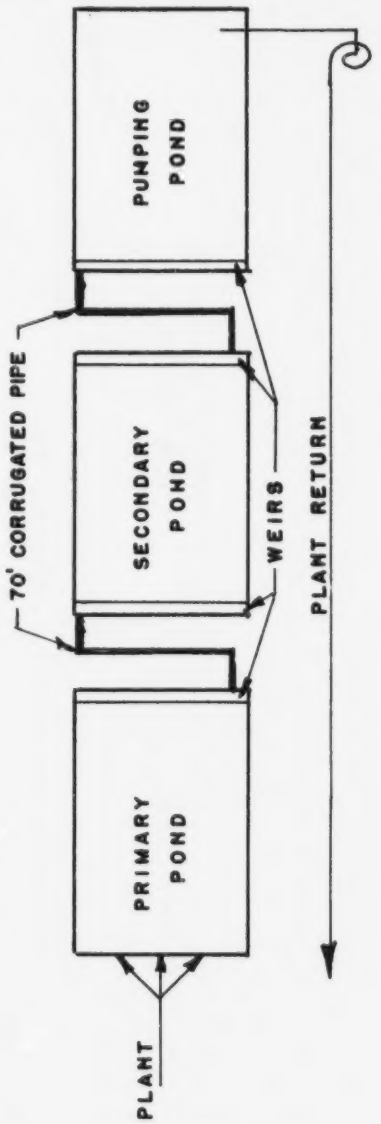


FIGURE NO. 25 PLANT LAYOUT

Some of the chemicals which are available are listed in the appendix.

There are a multitude of choices to be made in determining which chemical should be used. An engineering firm familiar with the available chemicals and plant problems can make an unbiased evaluation. A chemical company with whom the plant operator would like to do business can be of help. The cost of clarifying the water can be very expensive so it must be insisted that low-cost coagulants, such as alum and lime be tried.

The ideal plant waste water system is one that is also rehabilitating land. With this system, the primary pond becomes the land that is being rehabilitated. If a high percentage of solids is in the discharge and they settle out quickly, no chemicals should be put into the discharge water until it leaves the primary pond. The reason for this is to avoid wasting chemicals on solids which will settle out quickly by themselves. This places larger, more stable material at the top of the rehabilitated land, making a better fill. If very little settles out quickly, the chemical can be introduced at the plant discharge and a corrugated pipe used to create a mixing action before reaching the pond. Most plant conditions will be such that coagulants should be added between the first and second pond. Providing adequate mixing economically becomes a problem.

The water should discharge from the primary pond over a weir that is a minimum of one foot wide for every 25 GPM. The chemical should be mixed with the water at the weir and then allowed to travel a minimum of 70 feet in a corrugated pipe that will cause mixing. The mixture of coagulant and water will then flow into the secondary pond and as it slows and spreads out, flocculation will begin.

Pond minimum sizes can be determined from Figures 27 and 28. The most desirable pond size should be determined by available land and cost of developing pond. The larger ponds will last longer, but land rehabilitation will progress at a slower rate.

Frequently the plant operator does not have the need for rehabilitating the land nor the room for large ponds. In this case he must use the largest ponds his land will allow and haul away the sediment as it builds up in the primary pond. A second primary pond is required to be used while the first pond is idle for the drying and removal of built up sediment. Overflow from the primary ponds flows into a pumping pond. With this system coagulants are usually

mixed ahead of the two primary ponds. A typical plant layout is shown in Figure 26.

The primary ponds can be sized as shown on Figures 27 and 28. The pumping pond should be large enough to meet the plant's water surge demands.

The primary pond cross section can be sized by limiting the flow to a velocity of approximately one foot per minute and making the pond twice as long as it is wide. If more specific information is desired relative to anticipating the sediment that will occur in the primary pond, refer to the section on settling ponds. Larger ponds can be used if desired to increase pond life or increase sedimentation.

The ponds must also have sufficient holding time to be effective. From the jar tests an estimate can be made for the time needed for clarification and the pond can be sized accordingly. The available land may cause the operator to use a different mixture of coagulants to fit available pond size.

Example, Figure 25

Known, water use--2,500 GPM. The water specific gravity is 1.010. It is known that the large particles will drop out quickly.
The jar test shows 60 PPM alum and 4 PPM of commercial polymer caused good clarification in three hours. Specific gravity was down to 1.000 and water cloudy in one and a half hours. By doubling the alum, clear water was obtained in one and a half hours.
Minimum pond size from Figure 27.
Water flow is one foot per minute.
Figure 27 shows 340 square feet cross section or 50 feet wide, 6.8 feet deep and 100 feet long.
Check holding time with Figure 28--one and a half hours holding.

Figure 28 shows 60,000 cubic feet--70 feet wide, 6 feet deep and 140 feet long. (Additional depth is required for storage of sediment). The operator must decide whether clear water is necessary or if cloudy water is acceptable. If land is available, three hours of pond storage would reduce coagulant requirements.

At this point it must be decided how the land will be used. If this example is for an operation where land can be rehabilitated, there would be a primary pond 70 feet by 6 feet by 140 feet. (The contour of the land would determine the actual width and depth). The chemical would

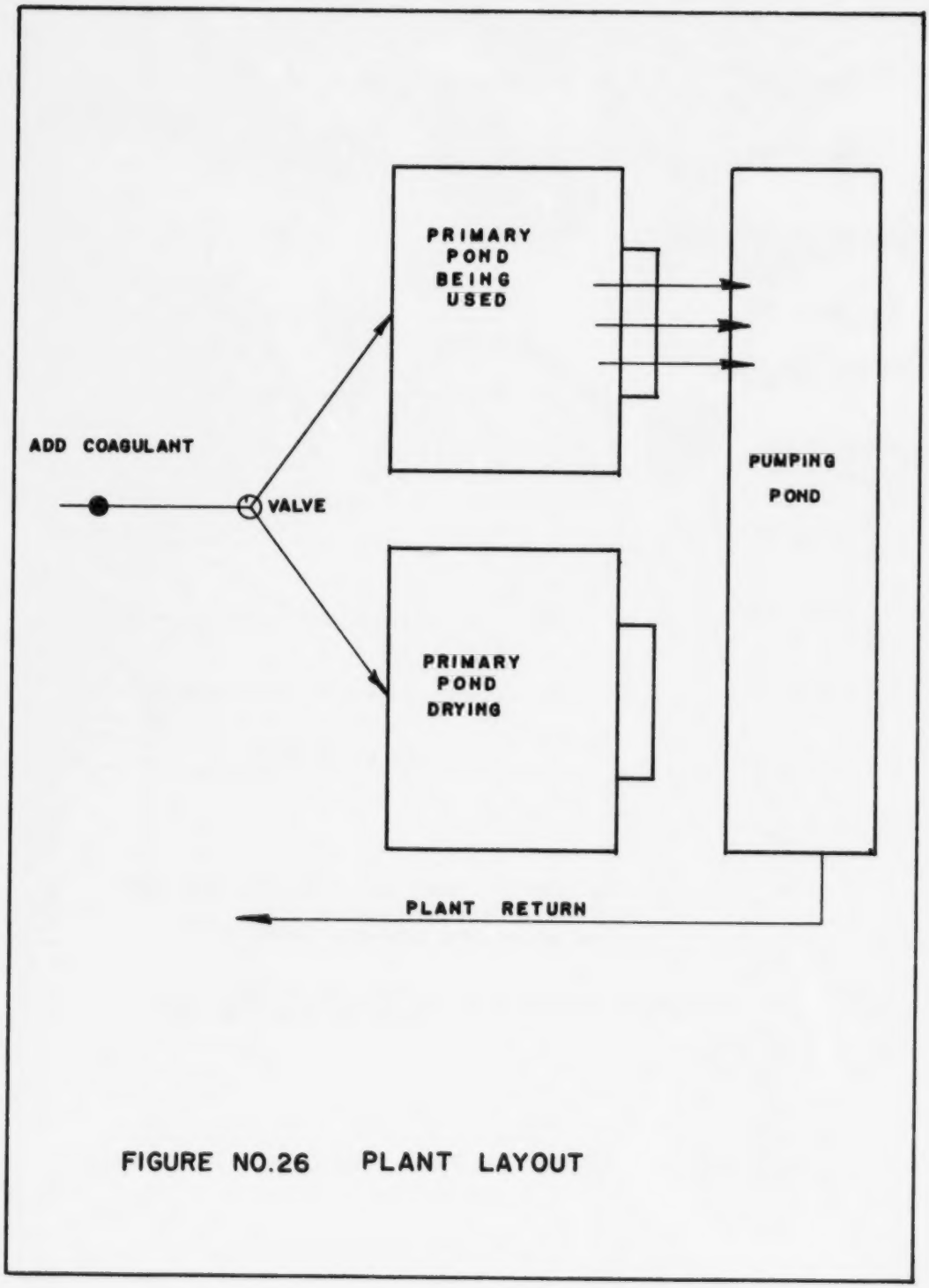


FIGURE NO.26 PLANT LAYOUT

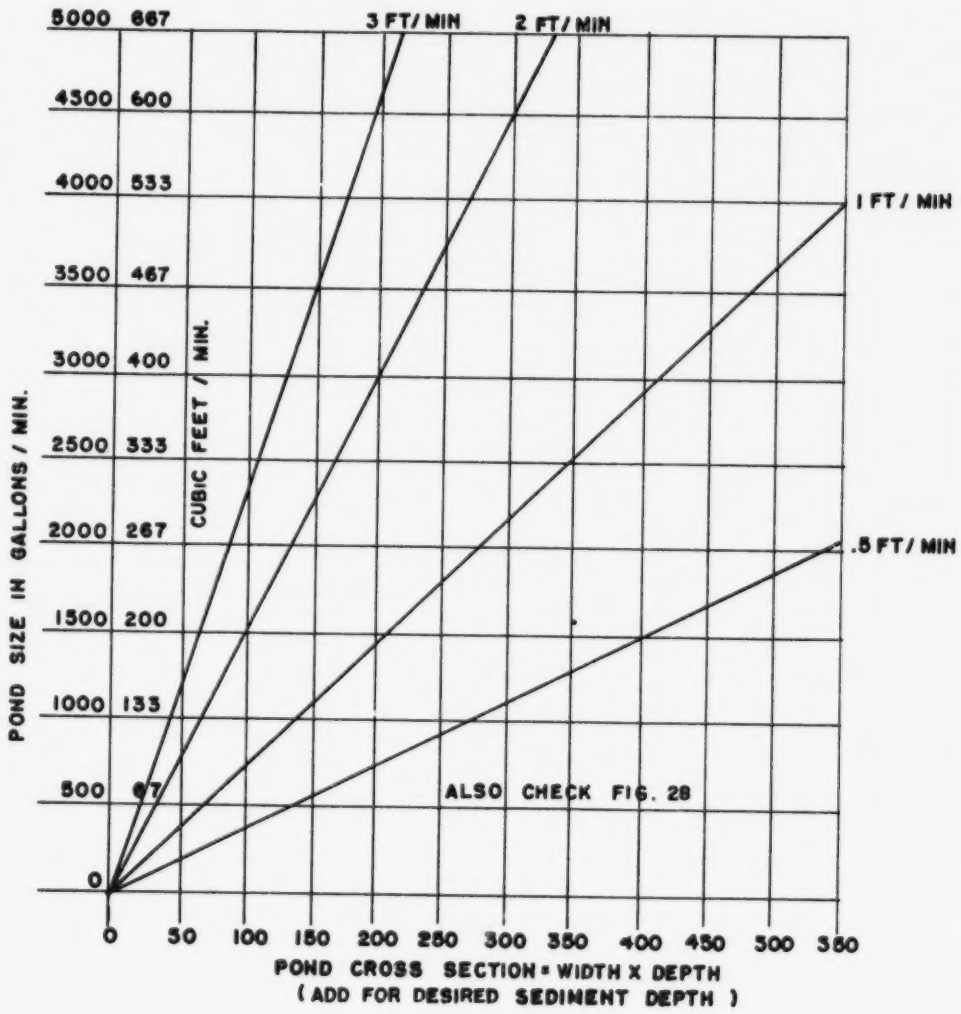


FIGURE NO.27 CROSS SECTION - COAGULANT POND

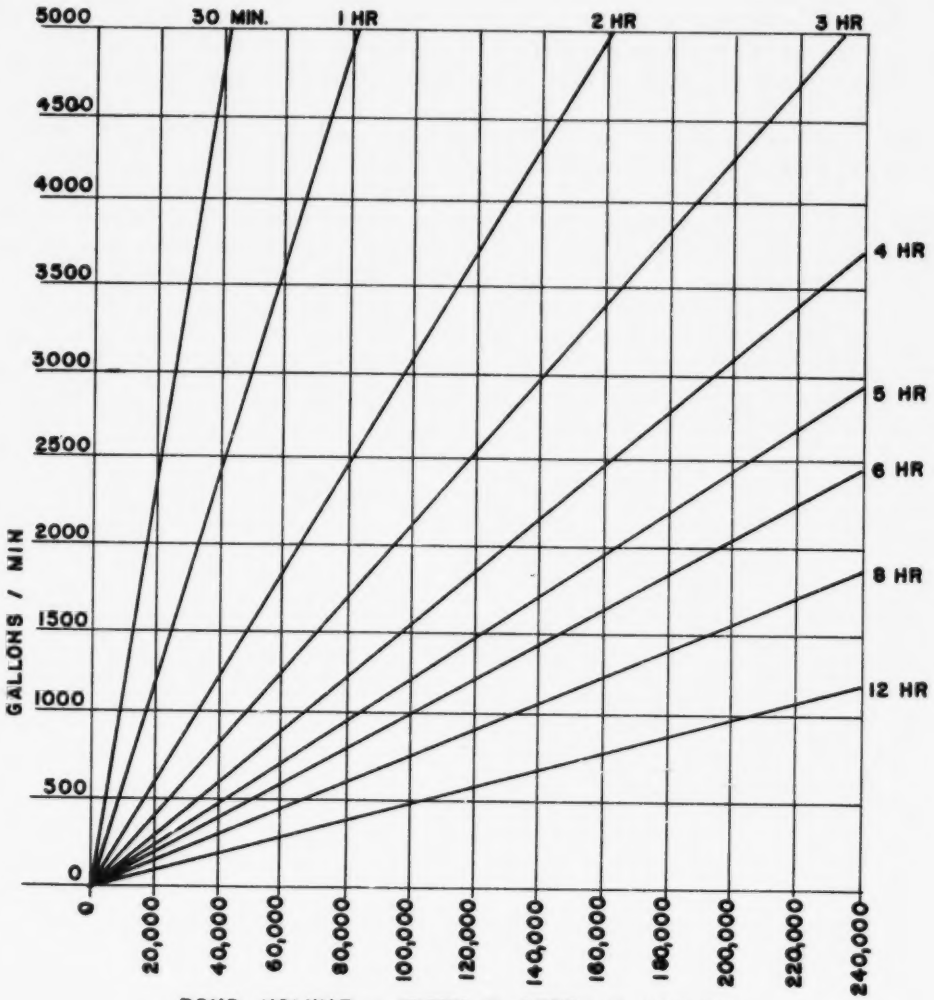
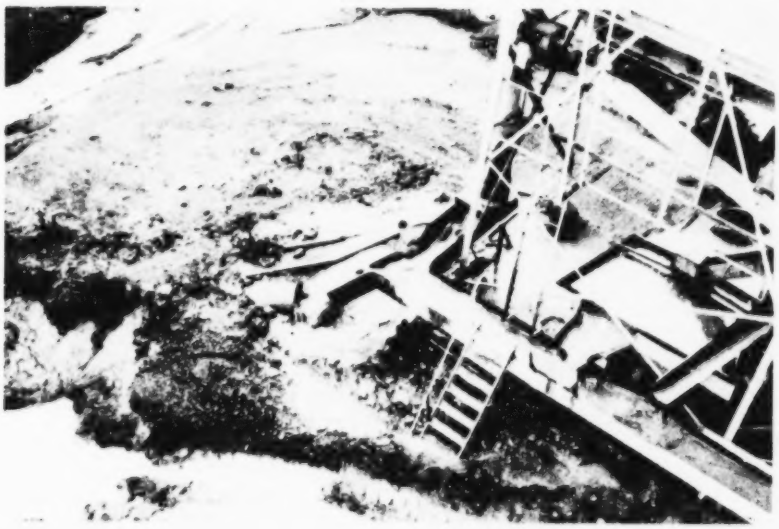


FIGURE NO. 28 COAGULANT POND VOLUME

be added between the primary and secondary ponds. The secondary pond must also be 70 feet by 6 feet by 140 feet to allow solids to settle. The pumping pond needs only to be large enough to have surge storage of water, but often it is less expensive to make another 70 feet by 6 feet by 140 feet pond, since it will be the next secondary pond.

More frequently the ponds will be permanent and no land rehabilitation is possible. (See Figure 26). A pond 70 feet by 6 feet by 140 feet would be used with some depth added, perhaps four feet, for sediment. The water in the pumping pond would go either back to the plant or into a waterway. If it goes into the waterway, more coagulant may be required to clear the water sufficiently. If the pond is to be permanent, refer to section on settling ponds for pond build-up rates. This will determine how often the ponds must be cleaned so the ponds can be sized more wisely.



Most plants discharge the water at one location. Coagulants can easily be added and given good mixing.

FIGURE 29 COAGULANT MIX POINT

Although this system is too small, it can be very effective with the use of coagulants and frequent cleaning. Primary pond, secondary pond and pumping pond. Water is recycled.

FIGURE 30 COAGULANT BASIN

SECTION VIII

READY-MIXED CONCRETE WASTE WATER DISPOSITION

The ready-mixed concrete plant uses water primarily in the batching of the concrete and for washing out and cleaning the central mixer and/or mixing trucks.

The concrete batch consists of a mixture of specific proportions of sand, gravel, cement and water. These are weighed or metered directly into the mixer truck or into a central mixer which pre-mixes the material before discharging into the trucks. Chemical additives may be included in this mixture to increase the workability of the concrete, to aid in the setting, to protect it from frost or to color the concrete.

The general practice is to order slightly more concrete than estimated to do the job to prevent running short. In some cases the overage is dumped on the job site. In most cases, however, it returns to the plant in the truck to be either incorporated in the following order or flushed out as waste material. Disposition depends on the amount left in the truck, the length of time since batching, the consistency of the following order, and other factors. Most trucks are washed out and cleaned only at the close of the day's run or when discharging the waste material. The amount of waste varies, but has been estimated at 500 pounds.

The amount of water used in washing out and cleaning the trucks varies from 50 gallons per truck to several hundred gallons per truck, depending on the housekeeping practices of the individual companies. Water discharged from the washing operation contains sand and gravel and cement slurry and contains a pH rating of between 11.0 and 12.0 on the average. Clarification of this waste water consists primarily of lowering the pH factor and settling of the sand, gravel and cement particles. The pH factor for water being discharged into waterways is usually required to fall below the 11.0 to 12.0 average. Lime causing the high pH does actually act as a coagulant clearing the water.

Of those plants in the ready-mixed concrete industry which answered questionnaires, only a very small percentage had installed clarification systems. As in the aggregate industry, most of the plants use self-contained holding or filtration ponds on their own sites into which they discharge their waste water and material. The build-up of this waste material is used either to fill the pond

or pit or is periodically removed and hauled away as landfill material.

Water clarification generally consists of first removing the sand and gravel from the wash water and then removing the suspended fines and cement particles. The wash water also has a pH factor of around 10.0 to 12.0 and requires an acid treatment to neutralize it. Chemicals may also have to be used to aid in settling out the cement particles.

Those companies having clarification systems use several varying methods and arrangements. The general arrangement consists of a truck washing facility, a primary basin or pad to settle out the coarse sand and gravel and secondary basins or ponds to settle out the fines. Many of them also recycle all of the wash water.

Recycled water may be used to wash out the mixer barrel, but when used for washing the exterior may leave a white film which may be undesirable. A supply line of clean water may be installed in addition to the recycled line for the final rinse to eliminate the film.

The truck washing facility is dependent upon the housekeeping practice of the company, the amount of water used per truck, the number of trucks, the arrangement of the primary basin and many other factors. Trucks generally discharge their waste load and water in one of the following arrangements: (1) The truck discharges onto a waste pile where the water runs off or drains into the primary pond leaving the bulk of the coarse material on the waste pile. The truck in this case receives its water for rinsing from a separate source on the site; (2) The truck may back up to the primary basin, fill from a water source at that point and dump directly into the primary basin; or (3) The truck may back into one of several stalls located along a sloped paved apron which extends the entire length or width of the primary basin; after washing from water lines at each stall, the truck may dump directly into the primary basin or onto a sloping ramp which drains into the primary basin.

In some plants the trucks discharge their waste into a manufactured classifier or recovery unit with the overflow water running into the primary basin.

Primary basins seem to be generally of three styles. One type has a bottom which starts at the level of the washing pad and slopes away from the pad at about a 1:12 slope to a depth of around four to five feet. The wall at the deep end is slightly lower than the side walls and serves

as a weir. The sloping bottom aids in retaining the solids as they settle out and also enables clean-out with a front end loader.

One other type of primary basin is constructed with a flat bottom and a depth of five to ten feet or more. Some use a poured slab for the bottom while others use a gravel bottom. One side or part of a side is lower and serves as a weir. In some cases where the bottom is omitted, the basin also is used as a seepage pit.

The primary basin can also be in the form of a settling pond or pit with the water flowing over a weir or channel into the secondary basin or pond.

The main purpose of the primary basin is to settle out the bulk of the waste material, which is the gravel and sand. By so doing, the clean-out is confined primarily to this basin and the treatment of the water in the secondary basin becomes more efficient when coagulants are to be used.

The secondary basin is used to settle out the super-fine and cement particles. Again styles vary from a large settling pond to a single basin holding a one day's supply of wash water. The minimum basin seems to be one which will hold all the wash water for a maximum day's use. The water remains in the basin overnight and is pumped from the top of the surface downward in the morning until it starts to become cloudy. The water in this case is generally pumped to a storage tank or basin and recycled as wash water. The quality of this water in most cases will not meet the requirements necessary for discharging into a waterway.

Some plants use two secondary basins. Water from the primary basin enters one or the other of the two basins on alternate days. This arrangement allows the water to rest a full day and night in each tank before it is pumped out. Clarification of the water is greatly improved by this arrangement. However, due to the fineness of the cement particles and the high pH factor or alkaline content of the water, chemical treatment is generally required before the water will meet the standards required for discharging into a stream or waterway.

Because of the difficulty in bringing the quality of the discharged water within the required limits, most companies which have been discharging waste water into a stream or waterway are now discharging the water from the secondary

basin into a holding basin and recycling the water back as wash water, The secondary basins may be constructed below ground level in the form of a filtration basin to allow a percentage of the water to seep into the ground and to prevent an accumulation of waste water. Fresh water is used to augment the water from the basin.

When coagulants are used, it appears that they work most economically and efficiently if they are introduced into the flow of water from the primary to the secondary basin. The chemicals are prepared in a mixing tank and are metered into the flow of the waste water. Thorough mixing of the chemical additive with the waste water is of greatest importance in order to bring the chemical in contact with the greatest number of suspended particles.

The designing of a clarification system will require the consideration and analysis of all of the many variables. The first consideration probably would be the feasibility of eliminating the discharge of waste water from the plant site by installing a closed loop system. By recycling all the water the problem would be isolated or restricted to the plant area. Or perhaps by partial recycling, the decreased amount of discharged waste water could be treated to meet the required standards. Sizes and arrangement of basins are dependent upon the amount of water used, amount of ground available and the extent of clarification required. The use and amount of chemicals also is dependent on similar factors. Each plant needs an independant study and analysis of these factors to determine its own solution to the problem.

SECTION IX

READY-MIX FILTER PONDS

One of the simplest clarification systems is a filter bed. The filter most often would be rock. (3/4" to 6")

Figure 31 shows a rock filter that has worked very well. This water clarification system was designed for four wash stalls. The daily water usage is 20,000 gallons. The trucks dump wash water and waste materials into a ten foot wide basin. This basin is sloped so a front end loader can get in to remove the material. Enough water must be used to dilute the waste concrete that is dumped into this basin so the loader can pick it up. This coarse material basin needs to be cleaned about every two weeks. The cleanout is done after a weekend so the water has had time to settle out. A weir must be so designed as to allow slow drainage of the surface water as the basin becomes full. This will require some effort on the part of the operator to fill the entire length of the basin uniformly. The loader can remove the aggregate without running in water, which would damage brakes or bearings.

The filter pond is 60 feet by 60 feet by 16 feet, excavated out of a natural gravel deposit. This gravel provides an effective filter. Because cement does seal the walls and bottom, this seal must be broken about twice a year by excavating out the sediment and sealed gravel.

The pumping pond is 40 feet by 40 feet by 20 feet and is also in a gravel deposit. The water in the pond is clear and suitable for washing both the drum and the outside of the trucks.

The volume of wash water becomes important in the design of this system. If too little water is used, the coarse material will still retain cement and set up. This will create a problem in cleanout. Using too much water will increase the flow rate in the filter pond. Cement particles will flow across the pond and will quickly seal the wall next to the pumping pond. Settlement rates should be checked in order to size the filter pond. Table 3 shows the settling rates of sand and cement.

Example, Figure 31.
To check this plant for correct size, it is assumed that the .0001 inch and larger cement particles must settle out

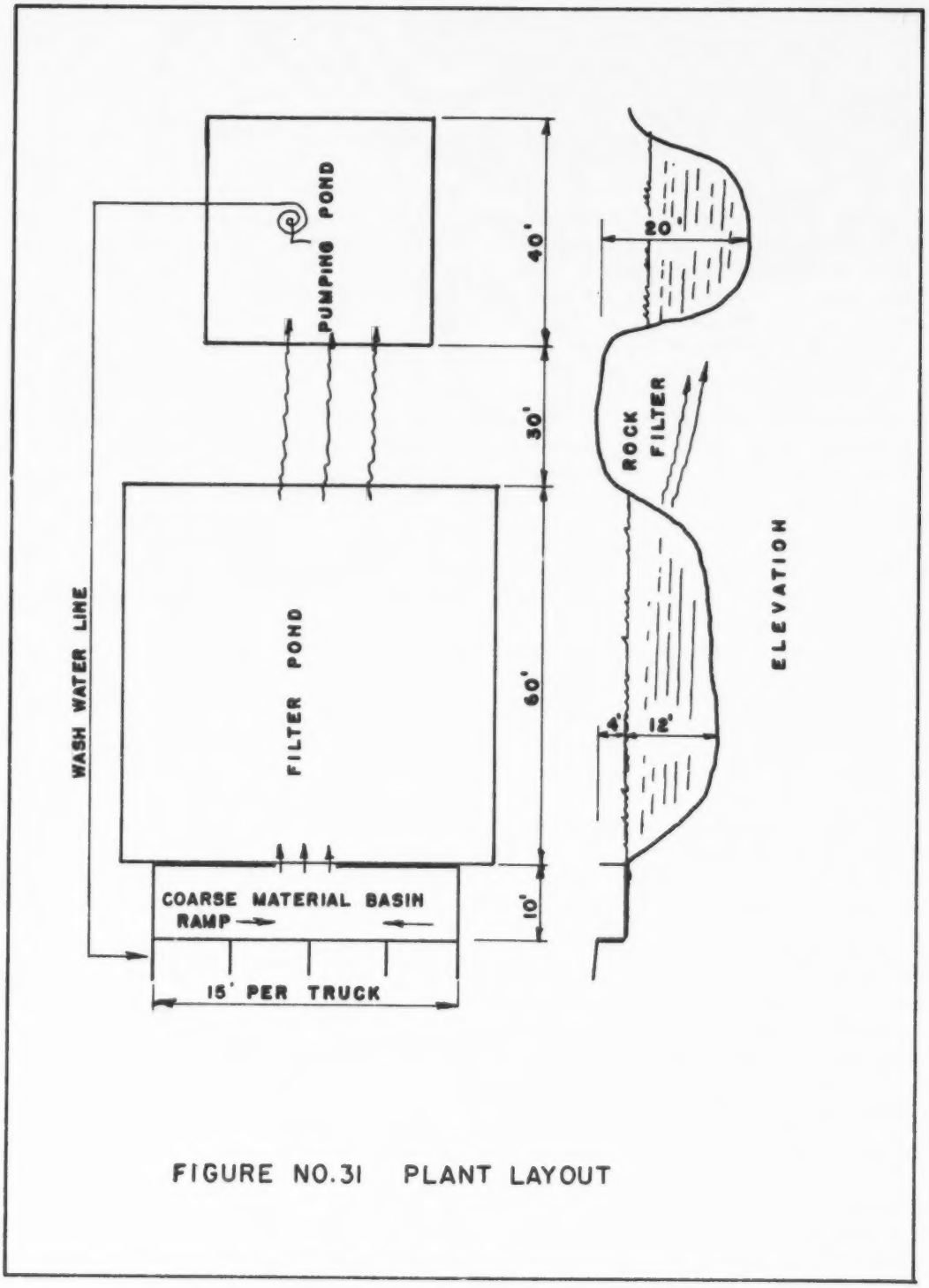


FIGURE NO.31 PLANT LAYOUT

ahead of the rock filter and that the water volume is 20,000 gallons or 2,670 cubic feet/day.

Surge storage is dependent upon water table, surface water, depth of pumping pond, etc. This system should not be used where the water table is close to the surface. The coarse aggregate basin has no surge storage because it will be full of aggregate at times and should be designed to allow the water to drain out of this basin. In order to achieve this the water level in the filter pond must not be higher than the bottom of the coarse aggregate basin, except during the washout operation. This allows a surge storage of 60' x 60' x 4' = 14,400 cubic feet. This is much more than the one day of surge storage required.

$$\text{Horizontal velocity} = \frac{\text{Water volume}}{\text{Cross sectional area}}$$

$$= \frac{2{,}670 \text{ cu ft} \cdot 1 \text{ day} \cdot 1 \text{ hr}}{12' \times 60' \cdot \text{day} \cdot 24 \text{ hrs} \cdot 60 \text{ min}}$$

$$= .00257 \text{ ft/min}$$

The horizontal velocity is well below the allowed .04 feet/minute allowed on Table 3.
Vertical settling rate from Table 3 is .00148 feet/minute.
Pond volume = 60' x 60' x 12' = 43,200 cubic feet.

$$\text{Retention time} = \frac{43{,}200 \text{ cu ft}}{2{,}670 \text{ cu ft/day}} = 16.2 \text{ days.}$$

$$\text{Time required for settling} = \frac{12 \text{ ft}}{.00148 \text{ ft/min}}$$

$$= 8{,}100 \text{ minutes or } 5.6 \text{ days.}$$

These ponds are usually only about 50 per cent efficient due to the short circuiting of water, and also because of the filter rock allowing water to filter out before it has had time to settle.
Actual time required for settling = 5.6 days/50% = 11.2 days.

The pond is slightly oversized, but this is not a loss in that this increases the pond life before sealing and allows for some sediment build-up.

This clarification system could also be used next to a waterway with the water filtering into the waterway and eliminating the pumping pond. However, some acid should be added to decrease the pH factor.

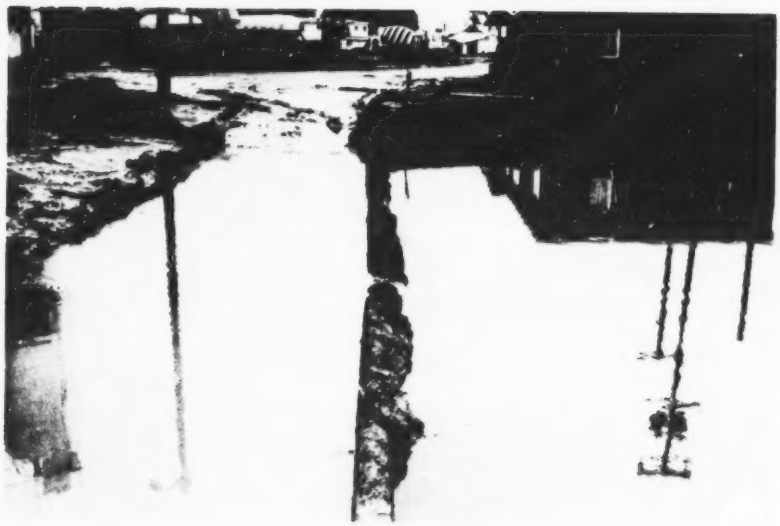
TABLE 3

SEDIMENTATION RATES

Diameter of Particle (Inches)	Description	Specific Gravity	Settling Velocity Ft/Min	Allowable Maximum Horizontal Velocity Ft/Min
.01	Fine Sand	2.65	11.4	4.0
.001	Cement	3.15	.148	.4
.0005	Cement	3.15	.0372	.2
.0001	Cement	3.15	.00148	.04

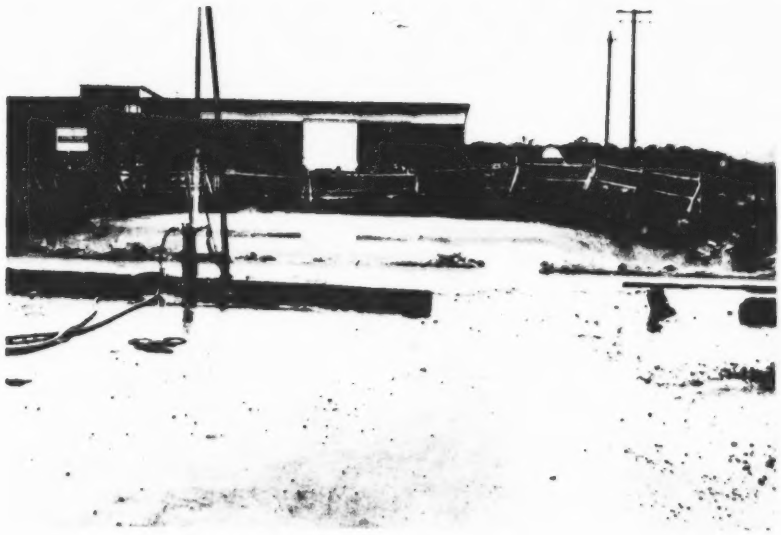
Note: Actual tests indicate that cement settles somewhat faster than indicated above until it is about five days old.

From National Ready-Mixed Concrete Association Publication No. 116.



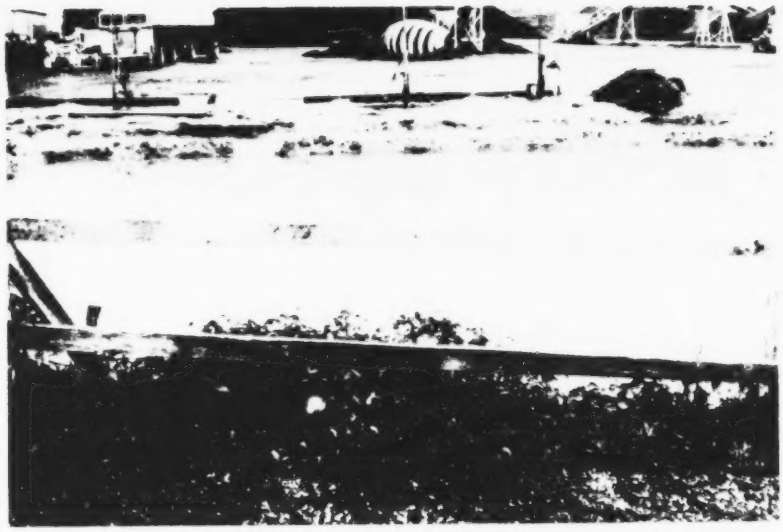
Wash rack on left, primary cleanout trough at center, and 60' x 60' x 16' settling pond at right.

FIGURE 32 READY-MIX FILTER POND



Wash rack in foreground, primary cleanout trough, 60' x 60' x 16' pond and recycle pumping pond beyond fence.

FIGURE 33 READY-MIX FILTER POND ARRANGEMENT



Recycle pumping pond behind camera, 60' x 60' x 16' pond in foreground, primary cleanout trough and wash rack in background.

FIGURE 34 READY-MIX FILTER POND ARRANGEMENT

SECTION X

READY-MIX SETTLING BASINS

Much has been done to develop workable settling basins for ready-mix plants. The National Ready-Mixed Concrete Association has surveyed some plants and printed the results. Through this study additional plants have been surveyed. This research has pointed out that the basins are quite similar, but each system seems to have some good and some weak points. For this reason, the systems will not be described exactly as they were put in, but rather they will be grouped together as to the better ideas and an attempt will be made to limit the weak points.

Example, Figure 35.
The cost of operating the following described closed system is about $50.00 per day. This plant operates with a very small system and uses very little water--70 gallons per day are used for drum washing and 20 gallons per day are used for outside rinsing for each truck. A fleet of 35 trucks uses approximately 3,000 gallons of wash water per day. Figure 35 shows arrangement of the water clarification system. An aggregate reclaiming unit and a settling basin are used to process mixer wash water and unused concrete. The coarse aggregate tends to remain on the upper portion of the slab while the cement, fine aggregate and water flow toward the lower end where the fine solids partially settle out. Cement-laden water flows around the end of the wall at the lower end of the slab into settling basin (B1), which is ten feet by ten feet by four feet deep. Cement settles in this basin leaving partially clarified water to flow from the basin as more water enters. The clarified water flows to a second basin (B2) and is allowed additional settling time. Water then flows to (B3) and is stored for reuse as wash water to be pumped out as needed.

Unused concrete in amounts over one-half cubic yard is loaded into a reclaiming unit (C) which washes out and separates the coarse and fine aggregate. The coarse aggregate is collected in a dump truck and returned to stock for reuse. The fine aggregate from the reclaimer is dumped onto the inclined slab to drain; and the cement and water flow to the settling basin. All the material collected on the inclined slab is picked up each morning with a front end loader and is either processed through the reclaimer or hauled to the dump.

Also each morning, the clear water on top of the second basin is pumped to the third basin. The sludge from the

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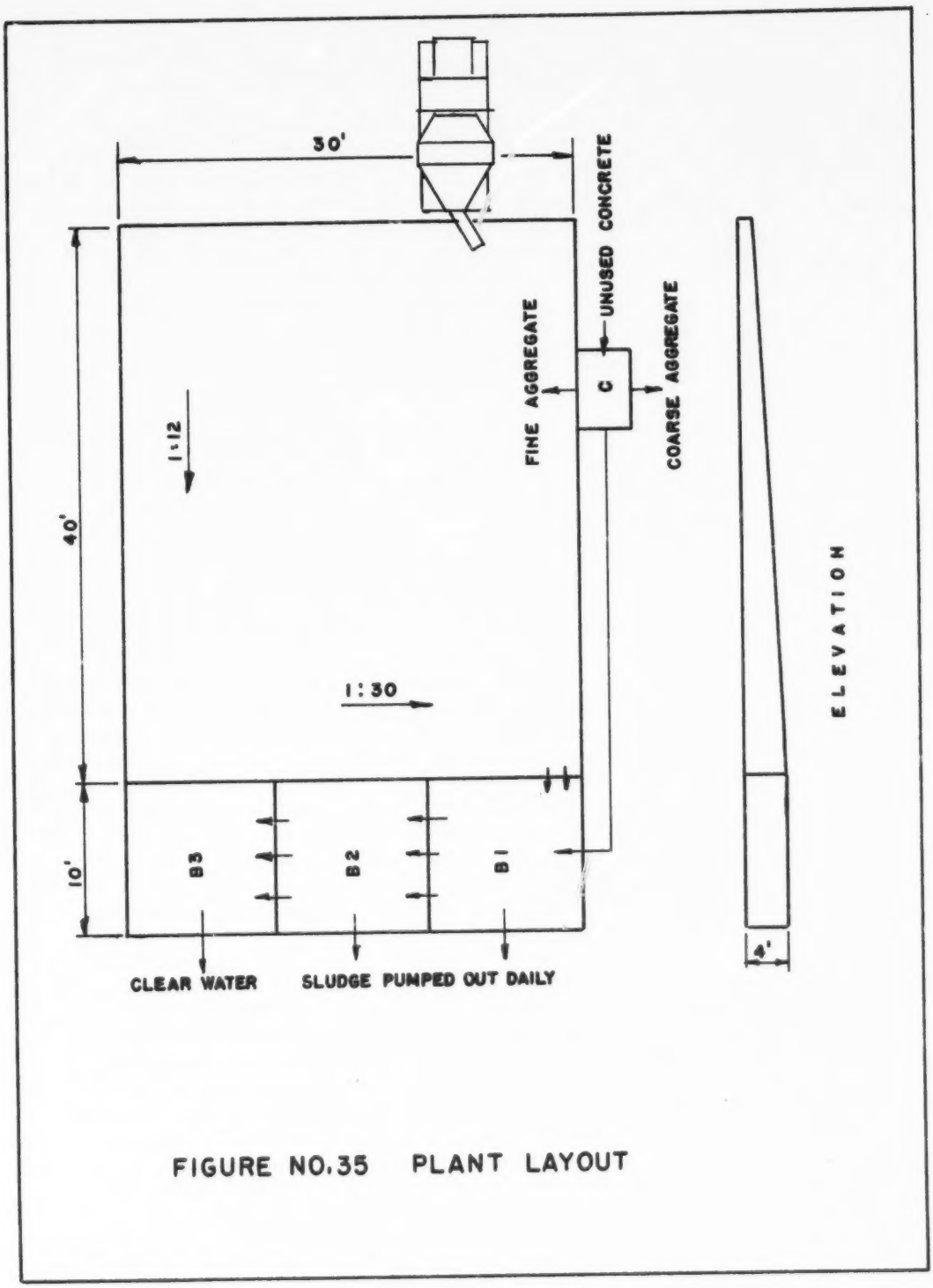


FIGURE NO.35 PLANT LAYOUT

first and second basins is pumped either into a tank truck and hauled immediately to landfill or discharged to allow drying just beyond the tank. Use of the tank truck eliminates the necessity of drying this material before hauling it away. In this case, one tank truck load per day is sufficient to clean the basin.

The washing time is four hours per day, so the 3,000 gallons/day flow is at the rate of 12.5 gallons per minute or 1.67 cubic feet per minute.

$$\text{Horizontal velocity} = \frac{\text{Volume of water}}{\text{Effective cross section of B1}}$$

$$= \frac{1.67 \text{ cu ft/min}}{10' \times 4'} = .042$$

Table 3, ready-mix filter pond section shows .0001 inch material will settle at .04 feet per minute, so horizontal velocity is acceptable.

$$\text{Basin length} = \frac{\text{Horizontal velocity x depth}}{\text{vertical velocity}}$$

$$= \frac{.042 \times 4}{.00148} = 11.4 \text{ feet}$$

Basins B1 and B2 act as settling ponds while B3 is a holding basin. The combined length of basins B1 and B2 is 16 feet. Sixteen feet is greater than the required 11.4 feet, so the basins are adequate. Basin B3 must be large enough to hold the surge which is a minimum of one day's water use. Most plants use much more water per truck so they would require much larger basins (B1, B2 and B3).

Example, Figure 36.
Many plants fill the truck drums full of water as a method of cleaning. This system requires about 1,300 gallons to fill an eight yard truck. Washing the outside of the truck requires another 400 gallons of water. In some plants these trucks will be washed out as often as twice a day. A 30 truck fleet using water at this rate will use 78,000 gallons for drum washing and 24,000 gallons for washing the outside of the trucks per day. For this type of operation using recycled water for drum washing and fresh water for the outside, might be the best answer. For an example, Figure 36 shows this type of plant arrangement with an eight truck wash rack. Using the above mentioned washing procedure and 30 trucks, the water volume per day is 78,000 + 24,000 gallons or 102,000 gallons. Assuming four hours for washing time, the flow rate becomes 424 gallons

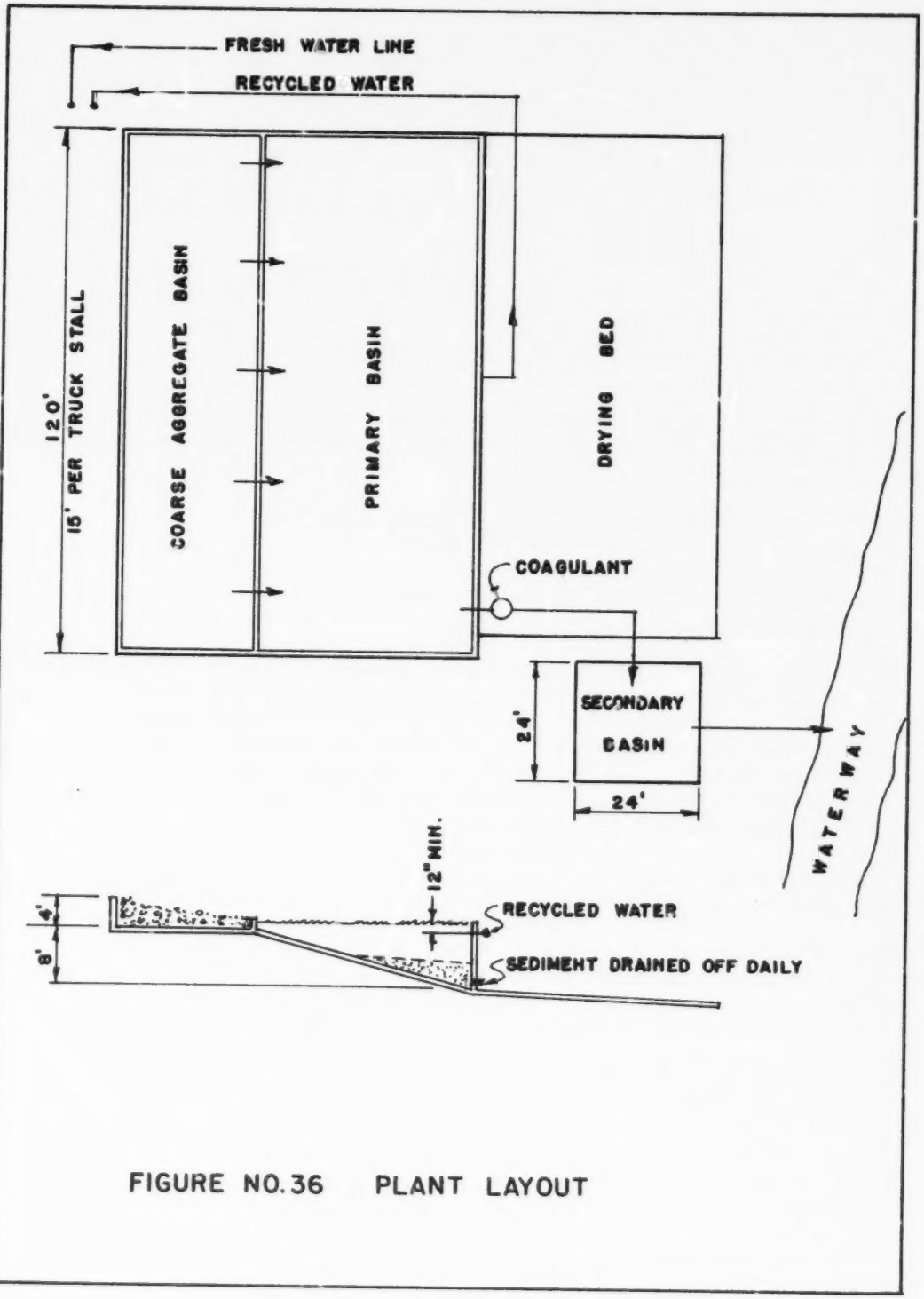


FIGURE NO. 36 PLANT LAYOUT

per minute or 57 cubic feet per minute. The basin is 120 feet wide, 16 feet long and 0 to 8 feet deep.

$$\text{Horizontal velocity in primary pond} = \frac{\text{Volume of water/min}}{\text{Effective cross section of basin}}$$

$$= \frac{57 \text{ cu ft}}{4' \times 120'} = .12 \text{ ft/min}$$

$$\text{Retention time} = \frac{\text{Flow distance}}{\text{Horiz rate of flow/min}} = \frac{16'}{.12} = 134 \text{ min}$$

Table 3, Sedimentation Rates, shows that with a maximum horizontal velocity of .12 feet per minute, cement particles with a diameter of about .0003 or larger will settle vertically at about .014 feet per minute.

With a retention time of 134 minutes, the particles larger than .0003 inches in diameter will settle a vertical distance of about two feet in the length of the pond.

Recycled and overflow water should contain suspended particles smaller than .0003 inches in diameter. Due to the abrasive action of the suspended particles a slurry pump should be used to recycle the water. Should the operator want to recycle water containing larger sized particles, the size of the basin could be decreased.

From the total volume of 102,000 gallons per day, 78,000 gallons are recycled. The remaining 24,000 gallons are overflow and must be treated before the water can be discharged from the plant. This contains the suspended particles under .0003 inches in diameter and also has a high pH factor. Chemicals must be added to aid in the settling and to neutralize the alkaline condition. A secondary basin must be used. Constructing the basin to contain a full day's capacity would allow the treated overflow water to be held overnight to clarify.

To contain the volume of 24,000 gallons or 3,200 cubic feet, the basin size could be 24 feet by 24 feet by 6 feet deep. Figure 41 gives approximate acid required to neutralize the water.

This water is now clear enough for discharging into the waterways, or possibly this water could be used for mix water, making it a closed system.

Example, Figure 37.
Some ready-mixed concrete producers reuse clarified water from their settling basins to conserve the limited water supply. Wash water and unused concrete diluted with extra

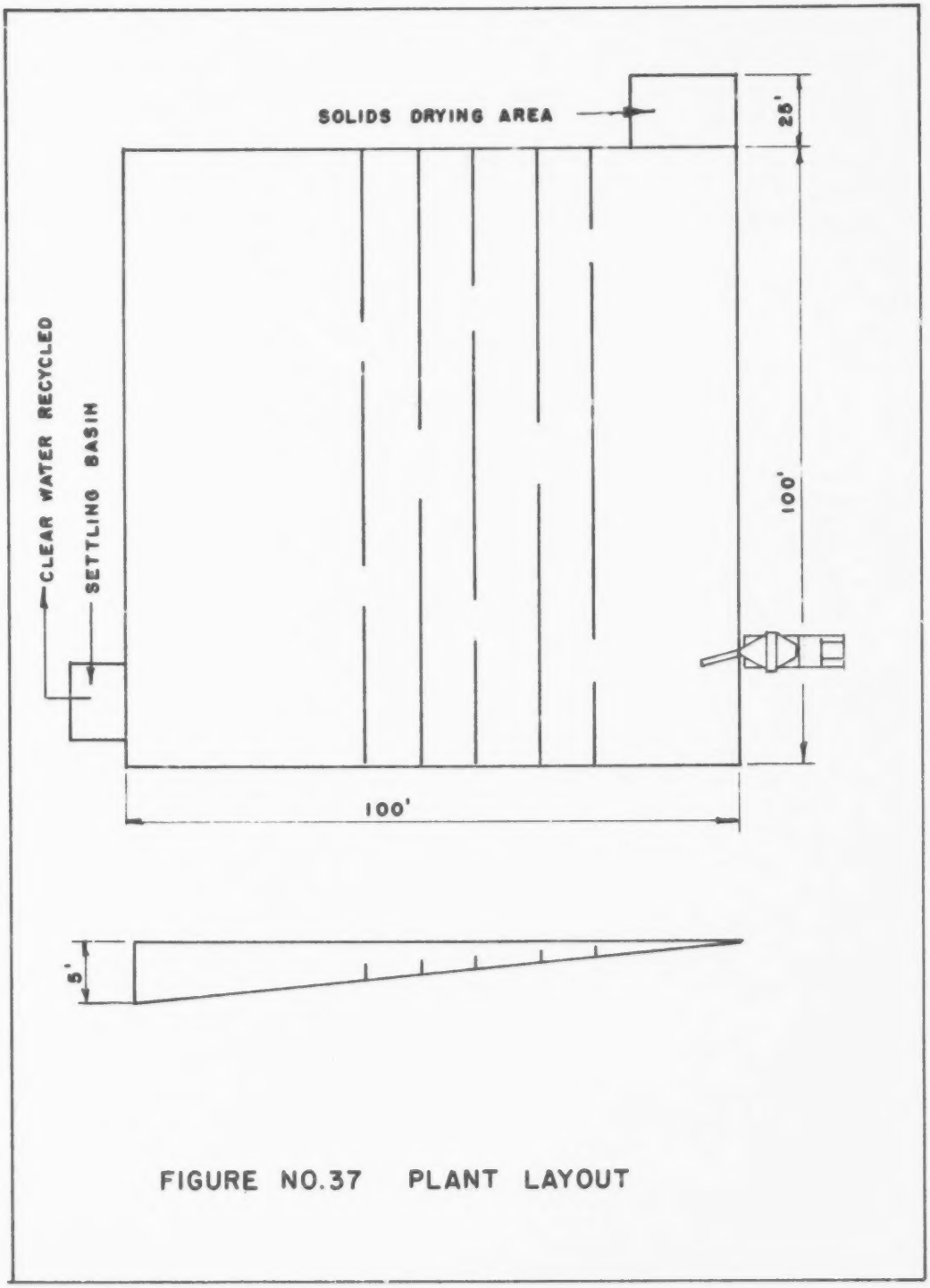


FIGURE NO.37 PLANT LAYOUT

water are discharged at the top of a 100 feet square inclined concrete slab which is divided into six bays by low concrete walls. (Figure 37) Openings in the walls are staggered so that the wash water drains slowly toward the lower end, depositing most of the solids on the way. Gravel, graded No. 4 to one inch, is piled in the wall openings and around the basin at the bottom of the slope to filter out the fine solids. Most of the solid material settles in the first two bays. It is pushed from the slab with a front end loader and piled alongside to dry. This material is hauled to a dump each week in dump trucks.

There is a settling basin, twelve feet by five feet by five feet deep at the lower end of the slab where most of the cement remaining in the water settles. The basin has valves at three elevations so that clarified water may be pumped from the top portion of the basin or sediment from the bottom. The clarified water is reused in the plant as mixing water.

Assume this plant to have 25 trucks using 500 gallons per truck. Total water use per day = 12,500 gallons or 1,670 cubic feet/day. If the basin can hold in excess of one day's water use, it will allow ample time for settling. Basin volume = 100' x 100' x $\frac{5}{2}$ = 25,000.

Basin is large enough.

Example, Figure 38.
Figure 38 shows a smaller ready-mix water clarifier using straw filter. This arrangement would be most suitable for the operator willing to change the bales of straw more often in order to reduce the original cost of installation and reduce the amount of land used.

The first basin is designed to remove the coarse aggregate just as was done with the rock filter design. The second basin provides retention time for settling solids before the water passes the straw filter.

In order to reduce the pond size, the pond should be designed to settle .0005 inch cement particles before passing the straw filter. The water volume is 8,000 gallons or 1,070 cubic feet per day for a two stall wash rack with a six truck fleet.

The surge storage = area x height of straw filter

= 30 x 20 x 2 = 1,200 cubic feet.

There is over one day's storage, so surge capacity is

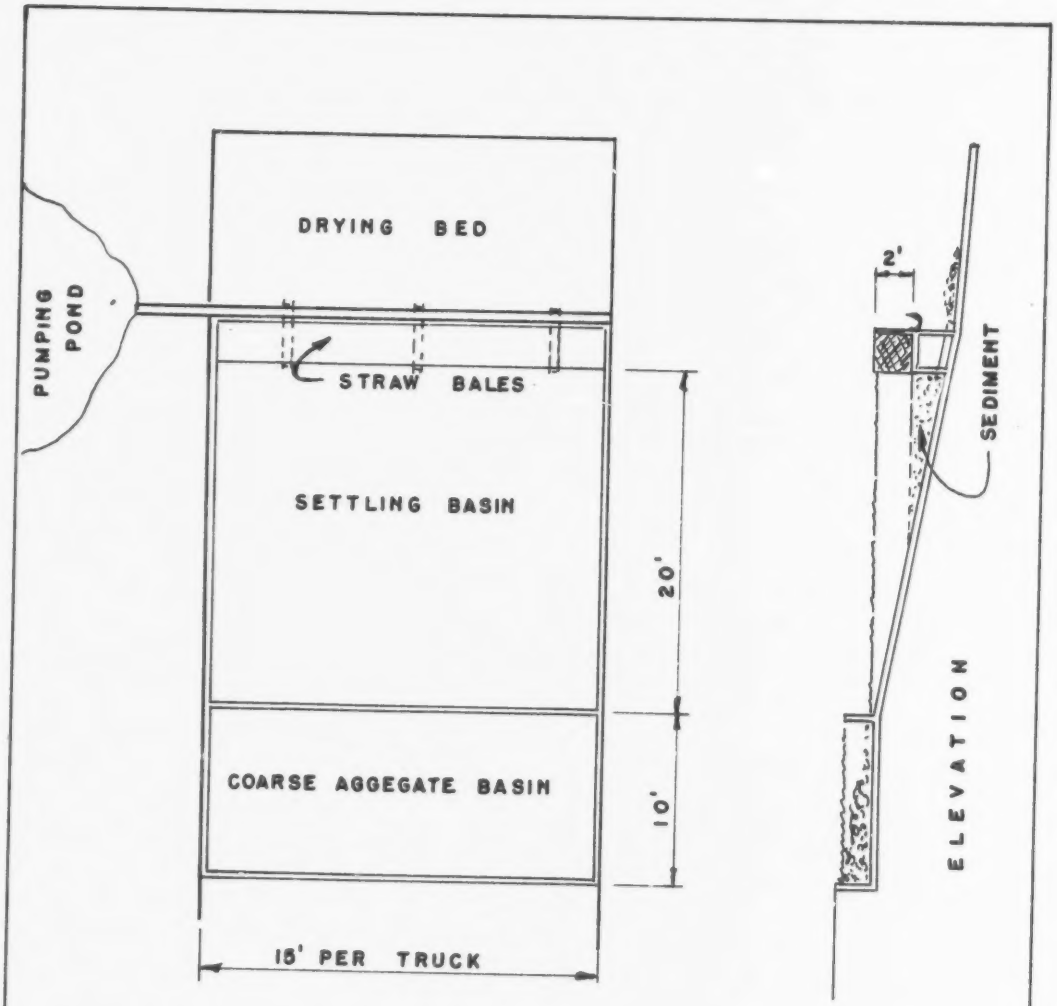


FIGURE NO.38 PLANT LAYOUT

large enough. Washing to be spread over two hours each day.

$$\text{Horizontal velocity} = \frac{\text{Volume of water}}{\text{Effective cross section of basin}}$$

$$= \frac{1{,}070 \text{ cu ft} \cdot \text{Day} \cdot \text{Hr}}{30' \cdot 4 \cdot \text{Day} \cdot 2 \text{ hr} \cdot 60 \text{ min}}$$

$$= .074$$

Horizontal velocity is less than the allowable .2 feet per minute shown in section on ready-mix filter ponds, Table 3. The pumping pond must have a minimum of one day's surge capacity.

The sediment can be drained off daily.

Example, Figure 39.
Here are a series of settling basins utilized in processing the waste materials to obtain fairly clear water which is discharged into a sewer. There is space for ten truck mixers at the wash rack (Figure 39). Wash water is discharged onto an inclined slab (A), and most of the coarser material accumulates there. The water and remaining solids flow into the first settling basin (B) through two additional basins (C and D).

Since most of the solids are deposited on the inclined slab (A), this area is cleaned weekly with a front end loader and the material dumped on another slab (E) for partial drying before being removed in dump trucks for use as fill. The other basins (B, C and D), containing fine sediment, are cleaned monthly using a front end loader assisted by a portable pump. Screens (S) are located at several points in the outfall to catch floating light-weight aggregate particles. About 120 cubic yards of material are hauled away weekly.

This system could easily have too high a flow rate, so it should be checked.

Assume a truck fleet of 25, each using 500 gallons per day or 1,670 cubic feet/day. Wash time is two hours, so it amounts to 14 cubic feet/minute.

$$\text{Basin cross section} = 30 \times \frac{5 + 0}{2} = 75 \text{ sq ft.}$$

$$\text{Horizontal velocity} = \frac{14 \text{ cu ft/min}}{75 \text{ sq ft}} = .186 \text{ ft/min.}$$

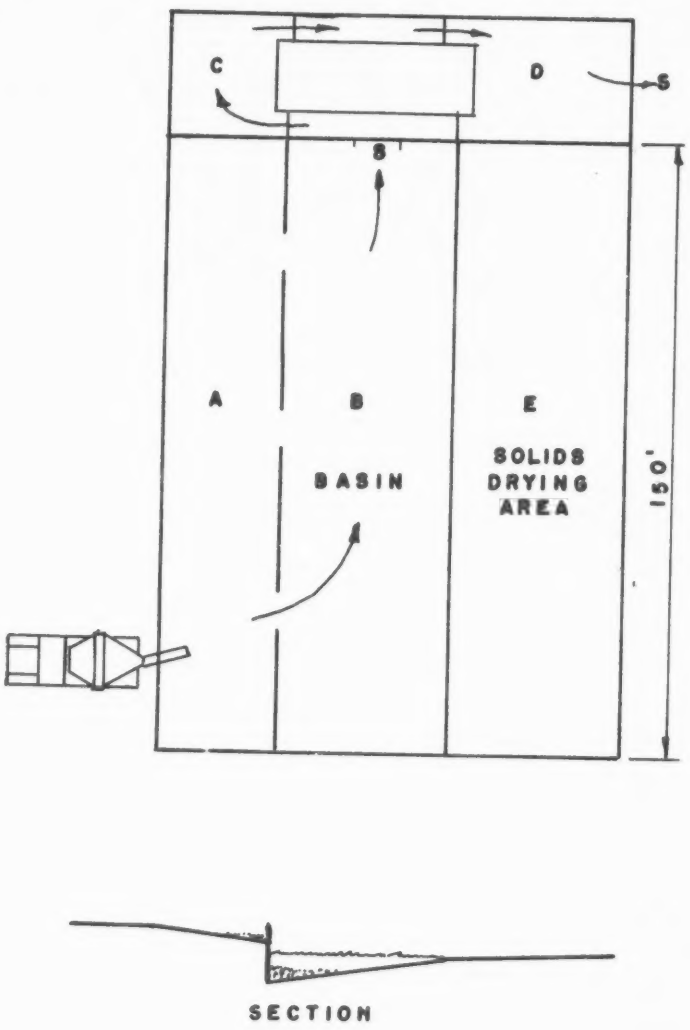


FIGURE NO. 39 PLANT LAYOUT

Particles as large as .0005 inch would not settle and in most cases would not be allowed in a sewer system.

Example, Figure 40.
Probably the most frequently used system is one where the waste ready-mix is dumped in a low area and the wash water is allowed to run off into a nearby waterway.

Frequently this system is not adequate, but with some modification it can be a very desirable one. The main advantages are: low initial cost and land rehabilitation. Figure 40 shows a typical plant layout. The primary pond should have one day's water storage plus the necessary land rehabilitation capacity. This means the primary pond should be quite large to avoid too rapid filling. The rate of buildup will depend on the amount of waste concrete discharged. The primary pond must have a minimum of one day's storage before water is reused. If the water is to be treated and discharged into waterways the secondary pond should also have one day's holding capacity to allow proper settling time.

The valves on the outflow pipes would be regulated to allow a constant and uniform flow for a full 24 hours. The most important design consideration is to provide enough cross sectional area in the ponds to establish a horizontal rate of flow sufficiently slow to allow the fines to settle. Assuming a ready-mix plant has 15 trucks using 40,000 gallons of water per day or 5,350 cubic feet per day. Maximum horizontal velocity from Table 3, ready-mix filter pond section is .04 feet per minute.

$$\text{Required cross section} = \frac{\text{Water volume}}{\text{Horizontal velocity}}$$

$$= \frac{5{,}350 \text{ cu ft/day} \cdot 1 \text{ day} \cdot 1 \text{ hr}}{.04 \text{ ft/min} \cdot 24 \text{ hrs} \cdot 60 \text{ min}}$$

$$= 93 \text{ sq ft or } 4' \times 25'.$$

A pond 4 feet by 25 feet in cross section is adequate, but because it would fill with sediment very quickly and because the pond won't be 100% efficient the actual size should be much larger. This size would be determined by the land conditions, but for this example use 4 feet by 80 feet by 160 feet.

There must be more than a day's surge from top of outlet pipe to top of berm.

$$\text{Height} = \frac{5{,}350 \text{ cu ft/day} \cdot 1 \text{ day surge}}{80' \times 160'} = .417 \text{ feet}$$

Use 1 foot.

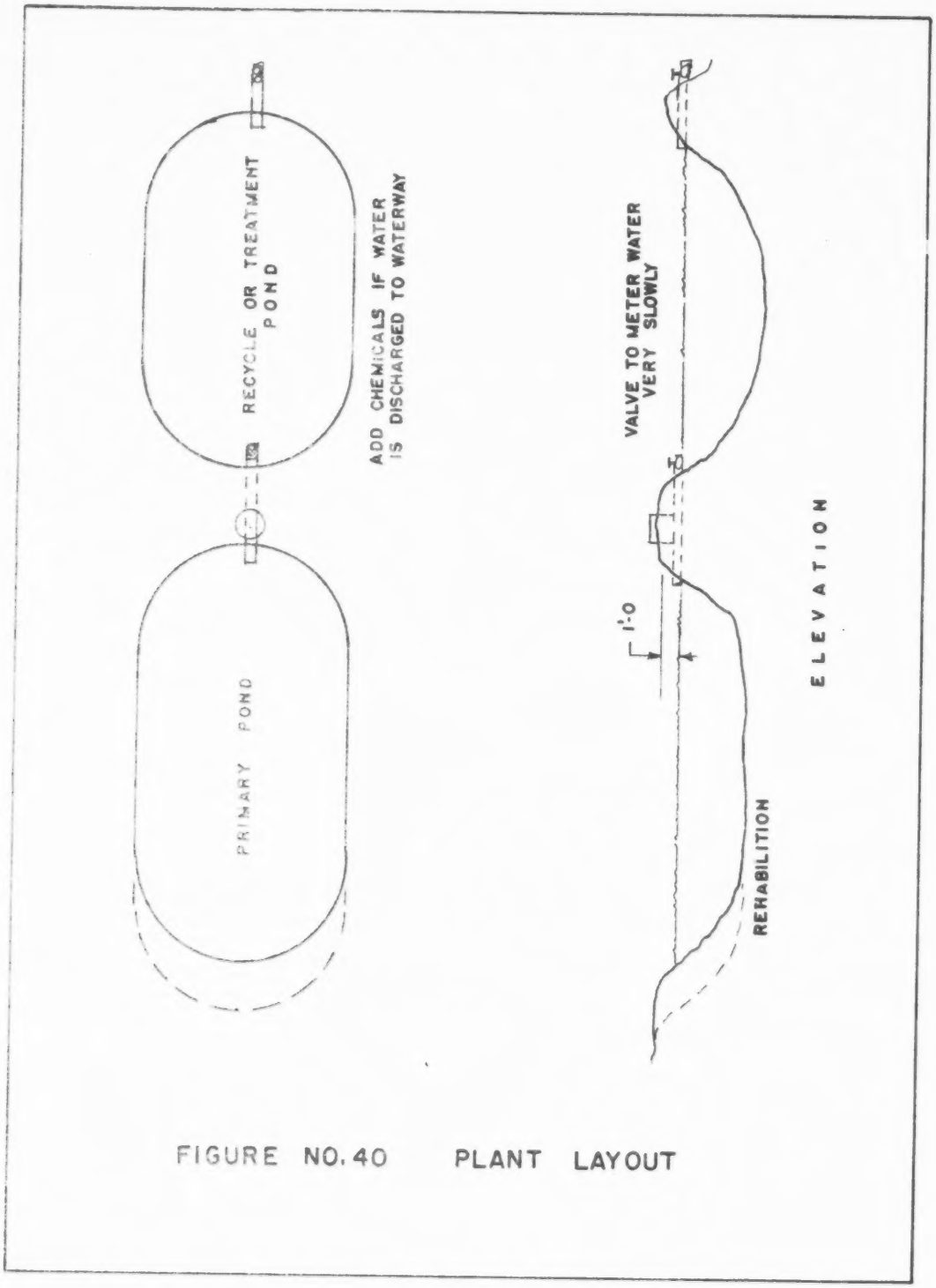
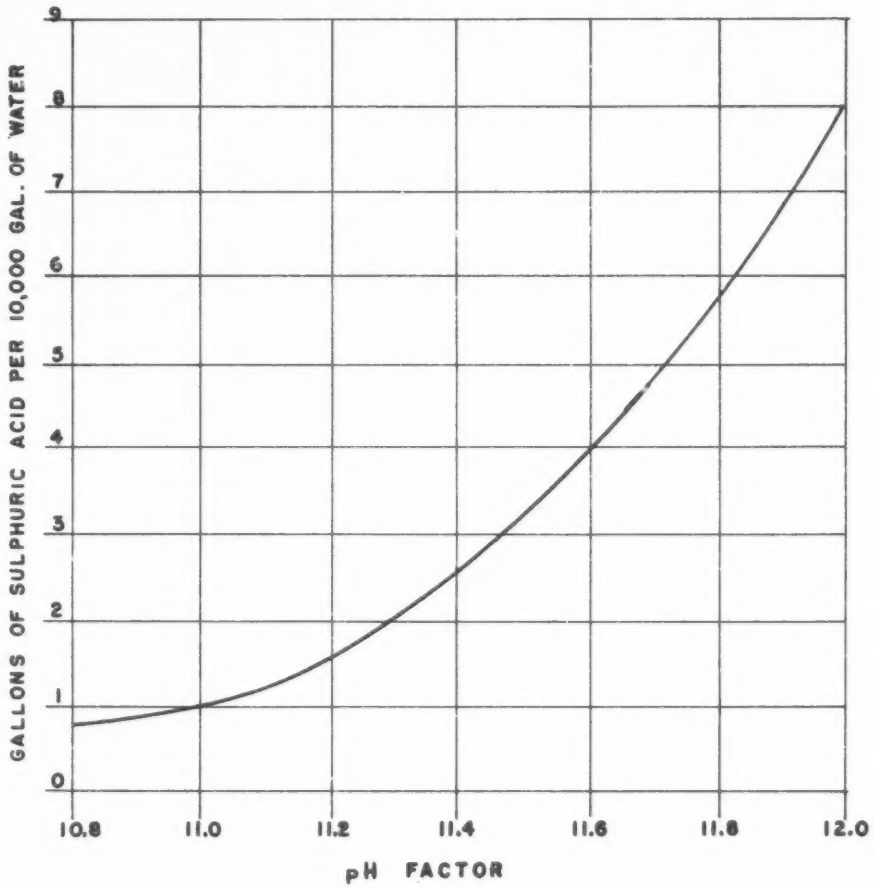


FIGURE NO. 40 PLANT LAYOUT



NOTE! AS THE pH FACTOR GETS LOWER VERY LITTLE ACID IS REQUIRED SO IT IS EASY TO OVERDOSE AND CAUSE THE WATER TO BECOME ACID.

DEVELOPED FROM FIELD AND LAB. TESTS

FIGURE NO.41 NEUTRALIZING READY MIX WATER

SECTION XI

READY-MIX WATER CLARIFICATION EQUIPMENT

Recently the manufacturers serving the ready-mix concrete industry have developed wash out systems. Most of these units are quite new and many need certain improvements.

The most popular type of clarifier is the drag chain type, see Figure 42. The truck drum is washed and dumped into the wash tank. The larger aggregates settle and are carried away by the first drag chain and stacked at the end of the washer. The finer aggregate and sand settle more slowly, thus carrying them to the second drag chain. The water is then recycled into the next ready-mix drum. This water is not clear enough to discharge into rivers, but will work well as a wash water for the insides of the mixer drums. The outside of the truck must be washed down with fresh water and some of this water can be collected and used for the make-up water for the washer. In most operations there will be an excess of water to clarify and discharge or use as mix water.

Manufacturers can also furnish aggregate screws which will separate the coarse aggregate and most of the sand, see Figure 43. The fine sand and cement particles will remain in the water and can be recirculated into the ready-mix truck drums or further clarified by weirs, settling basins, coagulants or filters. This system might be used by some operators because they may already have aggregate screws on hand. A further refinement to the system is to discharge the material from the screw onto a screen, see Figure 44. This allows separation of waste aggregates so they can be returned to the proper stockpile for reuse. If desired, the ready-mix truck can discharge directly onto the screen and the aggregate is separated, see Figure 45. The sand and water feed into a sand screw where the sand and water are separated. The advantage of this arrangement is if the plant has a sand screw on hand, but lacks an aggregate screw, the existing equipment can be used. This system also provides a larger capacity because only the sand goes through the sand screw. One disadvantage is that spray bars will be needed on the screen requiring additional water to be clarified. All these arrangements using screws will require a surge tank with capacity for as many trucks as will be washed at once. For example, if two trucks were washed at a time, each using a maximum of 500 gallons, the tank must hold at least 1,000 gallons. These washer units all salvage the aggregate for reuse. In the case of the screen, the material is separated by size for

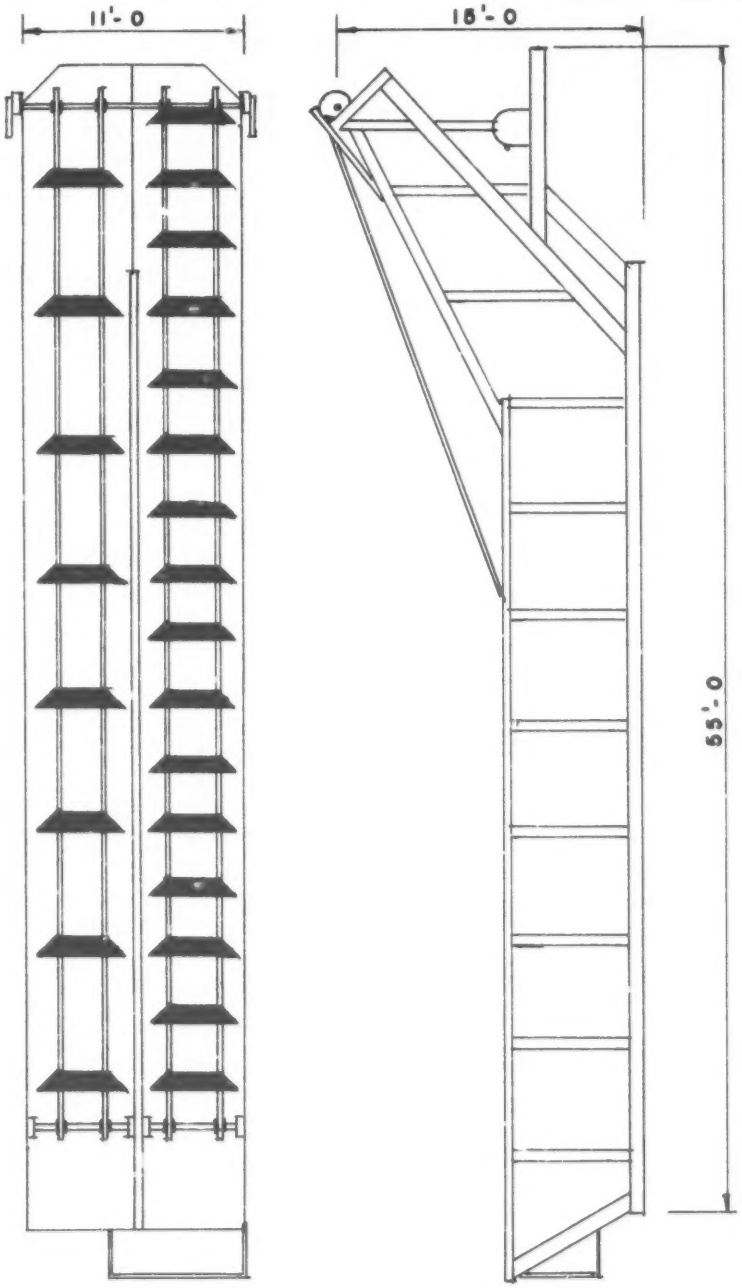


FIGURE NO.42 DRAG CHAIN WASHER

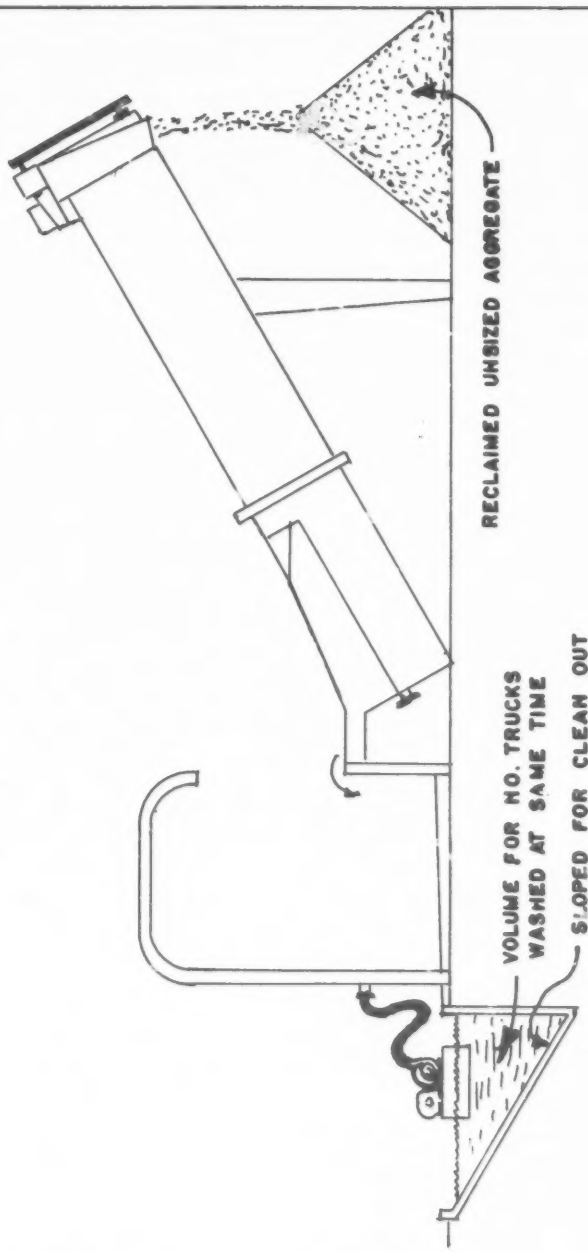


FIGURE NO. 43 SCREW WASHER

future use in the mix. The drag chain system, on the other hand, does not accurately grade the aggregate.

None of the units investigated clean the water sufficiently for discharge into the waterways. The content of suspended solids is too high as is the pH factor. Therefore, these units must be used as closed systems.

The washing of the outside of the trucks must be a separate system. The outsides of trucks will need less washing as time goes on, due to increased demands for dust control at plant sites. With less dust in the air, trucks will require less frequent washing.

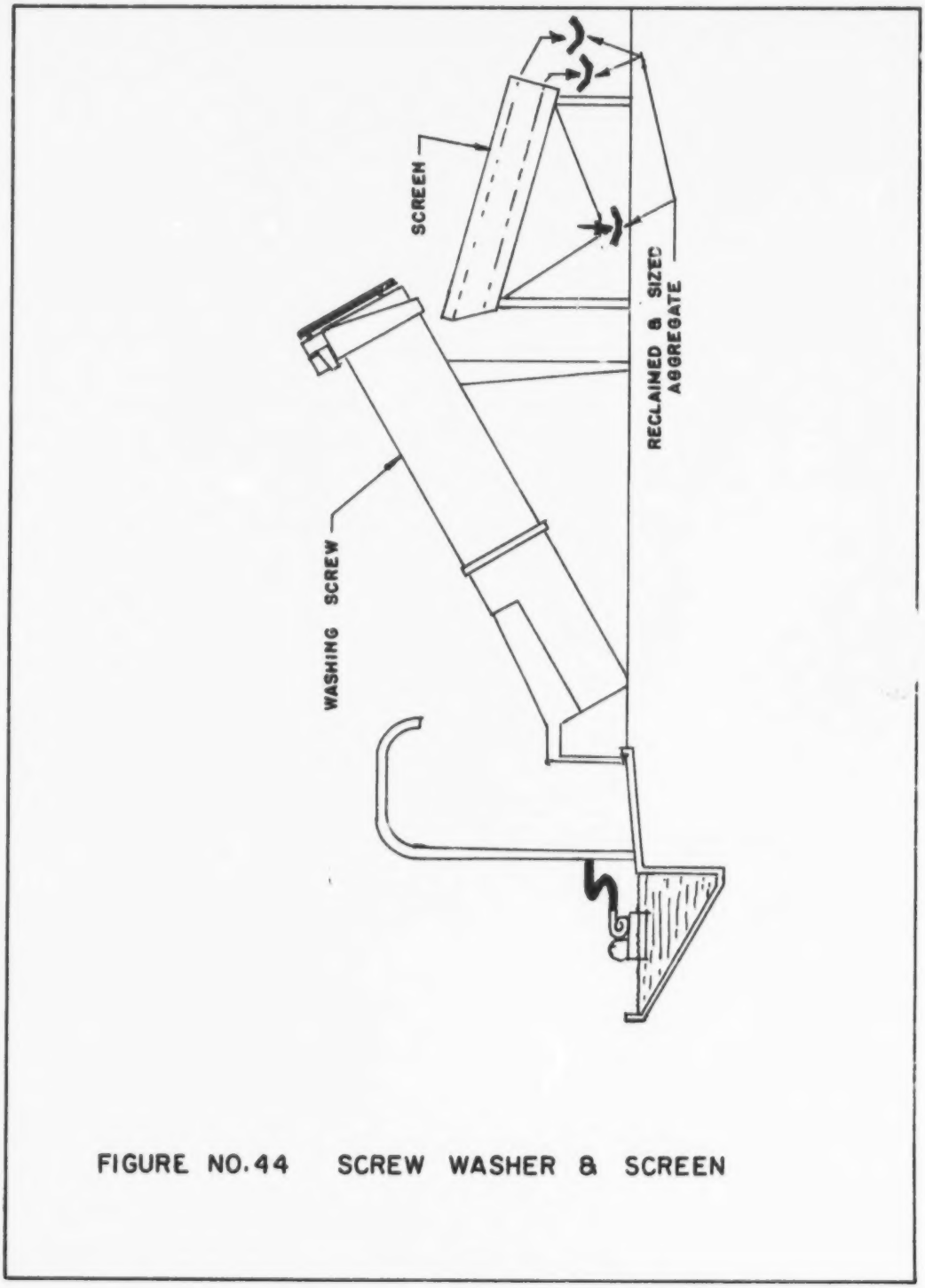


FIGURE NO. 44 SCREW WASHER & SCREEN

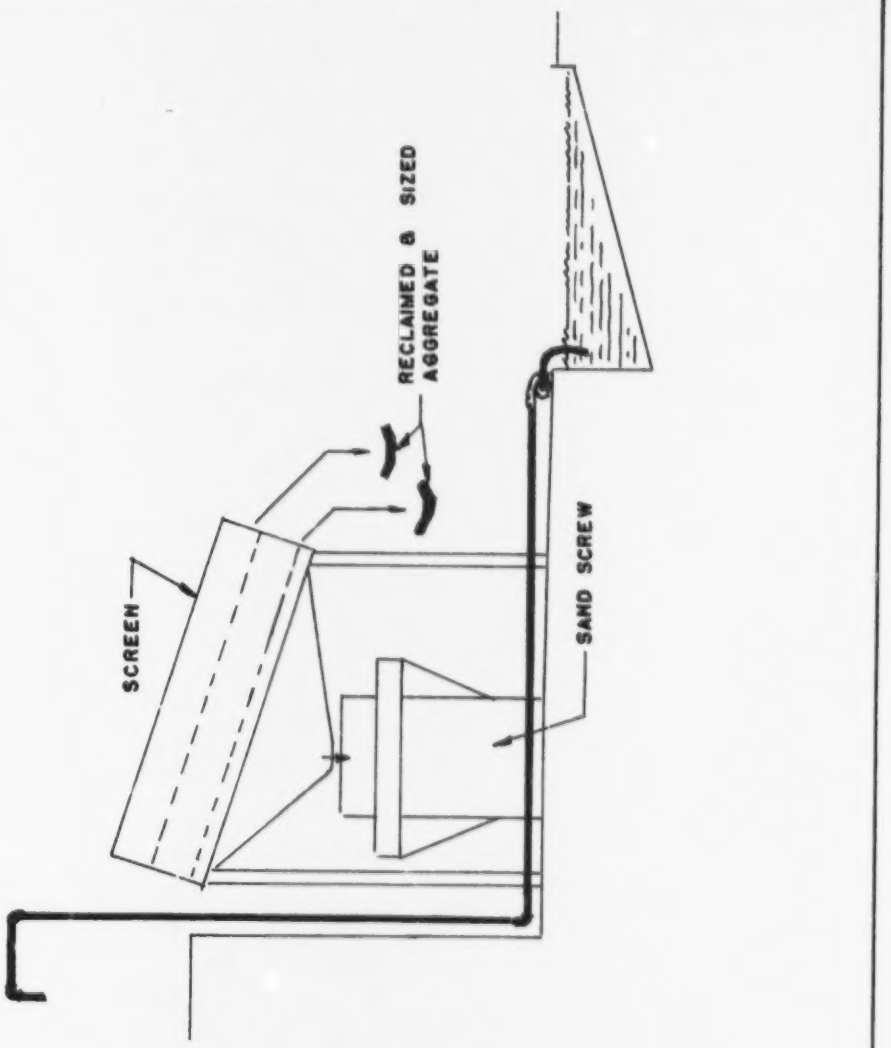


FIGURE NO. 45 WASHING SCREEN & SAND SCREW

SECTION XII

READY-MIX WASH WATER USED FOR MIX WATER

Although few plants are using wash water for mix water, this system should be considered because of possible economies and the fact that this system would eliminate all discharge into the waterways.

The American Society for Testing and Materials C94-67 makes the following definition of acceptable mixing water:

> 3.1.3 Water--The mixing water shall be clear and apparently clean. If it contains quantities of substances which discolor it or make it smell or taste unusual or objectionable or cause suspicion, it shall not be used unless service records of concrete made with it or other information indicates that it is not injurious to the quality of the concrete.
>
> Note 3--Information on the affects of questionable mixing water may be secured by testing mortar made with the water in question in comparison with mortar mixed with potable water of known acceptable quality in accordance with ASTM Method C87, Test for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar.

Wash water from ready-mix operations, when allowed to stand for short periods of time will become clear and apparently clean. There will be some cause for suspicion and if so, tests or service records could be used which should satisfy the user.

At least one plant has agitated the wash water to keep the cement suspended and has reported good concrete quality; however, clogged plumbing became a problem. Using slurries in such concentration to cause clogging would also raise a question as to the acceptance of the water as adequate mixing water. At least at the present, it appears more desirable to allow the aggregate, sand and cement to settle and be hauled away. The water would still be unacceptable for discharging into waterways, but should be very acceptable wash water. Extensive testing should be done so operators would be able to furnish this evidence in gaining approval to use their wash water.

SECTION XIII

COST OF CLARIFICATION

The cost of systems for clarifying water in the aggregate and ready-mix industries varies widely. The plant owners seem unable to establish realistic prices on their systems. Some of the factors that must be considered in arriving at the cost are:

1. Value of land used.
2. Cost of land development.
3. Cost of equipment.
4. Cost of operation.
5. Cost of maintenance.
6. Effect on plant production.
7. Change in water and sewer charges.
8. Cost of reporting to water control boards.

Many ready-mix plants located on expensive property in or near cities have very limited space. To use any of this land for a clarification system will make the production facilities less efficient. For this type of operation the only systems applicable and now developed are the manufactured units similar to the drag chain washer. A four-truck wash system of this kind, completely installed with paved area, water piping, electrical, concrete slab, pumps, etc., costs about $35,000.00.

Because most plants on high priced property are large operations, one unit would not be adequate. A 30 truck fleet should have two units in order to have a smooth operation. The land required for equipment and truck wash area would be 110 feet by 200 feet with allowance for turning on one side, and a pond area for treating the excess water before discharging into the stream. The cost of operation includes repairs, power consumption, removal of waste material by front end loader and trucks. The operating costs could vary from $10.00 to $100.00 per day, depending on the ability to sell some of the waste.

The ready-mix batch plant and component costs also can vary widely from $50,000.00 to $250,000.00. The minimum property size would be about 60,000 square feet. Property value could vary from $30,000.00 per acre to $100,000.00 per acre. There can be a wide variation in the cost per gallon of water to operate the plant inasmuch as the volume of water to be clarified ranges from 150 to 4,000 gallons of wash water per truck. It is apparent that the

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costs vary so widely that any averaging would only result in creating false impressions. The cost of clarification for some operators is a very small per cent of the total cost of doing business, while for others the cost is very high.

The aggregate plant clarification costs vary even more than the ready-mix operation costs. Some reasons for additional variations are:
Solids to be settled vary widely in specific gravity, negative charge and size.
Land availability varies more widely--some plants are rehabilitating land with these solids and the clarification can be profitable while others have little land and must pay to haul and dump the waste.
The natural deposits vary--some plants need no washing at all while others use several million gallons of water per day.

While an attempt was made in this survey to determine some average cost of clarification, no representative figures could be established. It appears that the price of the finished product will be increased substantially to include the cost of water clarification.

SECTION XIV

ACKNOWLEDGMENTS

Much support was given by the National Sand and Gravel Association, National Ready-Mixed Concrete Association and many of the state concrete and aggregate producers' associations. Many individual plant owners and operators gave valuable assistance. Chemical companies and manufacturers making clarification equipment were of help.

The financial support and technical and administrative guidance provided by the Environmental Protection Agency, Region X through the Project Officer, Mr. Edward G. Shdo was very helpful in making the project a success.

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APPENDIX I

Available Chemicals For Coagulation

Taken From
PROCESS DESIGN MANUAL FOR SUSPENDED SOLIDS REMOVAL

For
Environmental Protection Agency

By
Burns and Roe, Inc.

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AVAILABLE CHEMICALS FOR COAGULATION

Polyelectrolyte	Refer App II	Bulk Density lb/cu ft Loose	Pack	Work	Refer App III	Time to disperse into a coll. solution hour(s)	pH	Percent max solution concentration recommended
Aquafloc 409	AP	25	34	28	CNKL	1-2	4-5	1
Aquafloc 411	AP	42	53	45	CNKL	1-2	4-5	2
Aquafloc 414	NP	48	59	61	CNKL	1-2	7	2
Aquafloc 418	CP				DPKL	1-2	2.4	2
Aquarid 49-702	CM	33	44	36	E S	1-2	7-9	
Calgon C-2256	CP	30	43	34	DLKP	1/2	6.4	1.5
Calgon C-2260	CP	24	35	28	DLKP	1/2	6.7	1.5
Calgon C-2270	CP			25	DLP	1/2	7.3	1.5
Calgon C-2300	NP	10	16	13	BLN	3/4-1	7	0.5
Calgon C-2325	AP	10	16	13	BLN	3/4-1	7	0.5
Calgon C-2350	AP	11	19	14	BLN	3/4-1	7	0.25
Calgon C-2400	AP	10	16	13	ALKM	3/4-1	7	0.25
Calgon C-2425	AP	16	28	22	BLKN	3/4-1	7	0.25
Calgon WT-2600	CP	23	34	27	DKLP	1/2	4	1.5
Calgon WT-2630	CP	29	42	33	DKLP	1/2	4	1.5
Calgon WT-2660 (ST-260)	CP	27	39	31	DKLP	1/2	4	0.5
Calgon WT-2690	NP	9	16	12	ALM	1/2	7	0.5
Calgon WT-2700	AP	10	18	14	DLP	1/2	7.5	0.25
Calgon WT-2900	AP	8	13	10	AKLN	1/2	7.5	0.25
Calgon WT-3000	AP	16	29	22	AKLN	1/2	7.5	0.25
Hamaco 196	S	20	25	21	DLP	1/2-1	6-7	2
Hercofloc 810	CP	22	31	25	EKLR	1-2	6-7	0.5
Hercofloc 812	CP	21	31	24	EKLR	1-2	6-7	0.5
Hercofloc 818	AP	30	40	33	DKLN	1-2	8-9	0.5
Ionac NA-710	AP	38	47	40	CNL	1/2-1	5-6	1

AVAILABLE CHEMICALS FOR COAGULATION CONT'D

Polyelectrolyte	Refer App II	Bulk Density lb/cu ft Loose	Pack	Work	Refer App III	Time to disperse into a coll. solution hour(s)	pH	Percent max solution concentration recommended
Jaguar Plus	CG	31	40	22	FLPR	1-2	8-9	1
Magnifloc 530C	CP							0.5
Magnifloc 820A	AD	34	40	35	CLP	1-2	4.2	1
Magnifloc 835A	AD	30	42	34	DKP	1/2-1	6-7	0.1
Magnifloc 836A	AD	27	35	29	CKP	1/2-1	6-7	0.1
Magnifloc 837A	AD	28	36	30	DLP	1/2-1	5	0.5
Magnifloc 865A	AD	40	42	50	CLN	1 1/2-2	4.1	1
Magnifloc 870A	AD			28		1/4	7.5	1
Magnifloc 875A	AD			28		1/4	7.5	1
Magnifloc 880A	AD			26		1-2	5.5	1
Magnifloc 900N	ND	32	40	33	CLN	1-2	4.7	1
Magnifloc 901N	ND					1-2	4.7	1
Magnifloc 902N	ND					1-2	4.7	1
Magnifloc 905N	ND	27	35	29	CLN	1-2	4.7	1
Nalcolyte	P	26	40	31	DKLP	1/2-1	5.1	1
Nalco 633-HD	CP	42	68	52	DJLN	1/4-1/2	3	2
Nalco 636-HD	CP	45	53	47	DLN	1/4-1/2		1.5
Nalco 635	AP	38	50	41	DLN	3/4-1	8.5	0.25
Nalco D-2339	AP	39	53	43	DJIS	1/2-1	7.0	0.5
Nalcolyte 675	AP	35	50	40	DLN	1/2-3/4	8.5	0.25
Polymer F3	AG	32	40	34	DLN	1-2	9.5	4
Polyfloc 1100	AD	34	40	35	CKL	1-2	8.5	0.5
Polyfloc 1110	AD	36	42	37	CKN	1-2	7.5	0.5
Polyfloc 1120	AD	36	42	37	CKL	1-2	8.8	0.5
Polyfloc 1130	AD	35	48	39	DKP	1-2	8.8	0.5
Polyfloc 1150	AD	33	45	36	FJR	1/2-1	6-7	1

AVAILABLE CHEMICALS FOR COAGULATION CONT'D

Polyelectrolyte	Refer App II	Bulk Density lb/cu ft Loose	Pack	Work	Refer App III	Time to disperse into a coll. solution hour(s)	pH	Percent max solution concentration recommended
Polyfloc 1160	CD	34	40	35	CJN	1/2-1	5-6	1
Purifloc A-23	CD	42	53	45	BKP	1-2	10	0.5
Superfloc 128	ND	28	33	29	CLN	1-2	6-7	1
Tychem	ND			40		1-2	5.5-6	1.0
Tychem 8013	ND	33	43	36	CLN	1-2	6	1
Zeta Floc C	BC	48	68	54	EKR	1/4-1/2	8.2	1
Zeta Floc O	BN	52	74	59	EJR	1/4-1/2	8.2	1
Zeta Floc K	BC	48	68	54	EKR	1/4-1/2	8.5	1
Zeta Floc S	BC	54	78	61	E S	1/4-1/2		1
Zeta Floc WA	BA	54	78	61	E S	1/4-1/2		1
Zeta Flox WN	BN	54	78	61	E S	1/4-1/2		1

APPENDIX II

Chemical Characteristics

CHEMICAL CHARACTERISTICS

A -- Anionic
As-- Slightly Anionic
B -- Bentonite Clay or Clay, natural, colloidal-like type
b -- plus Bentonite
C -- Cationic
D -- Polyacrylamide, Synthetic, High M. W., Polyelectrolyte Polymer
E -- Polyacrylonitrile, Synthetic Polyelectrolyte
F -- Sulfonated Polymer
G -- Guar Gum, Polysaccharide, Natural Polymer
H -- High M. W., Organic Polymer
J -- Alkyl Guanidineamine Complex
K -- Sodium Alginate or Algin Derivative, Natural Polymer
L -- Leguminous Seed Derivative, Natural Polymer
M -- Polyamine, Synthetic, High M. W., Polyelectrolyte Polymer
N -- Nonionic
P -- Synthetic High M. W., Polyelectrolyte Polymer
R -- Polyacrylamide and Carboxylic Group
S -- Starch, derivative, Modified, etc., Natural Polymer
T -- Synthetic Polymer and Caustic Soda
U -- Sodium Carboxymethylcellulose, Natural Polymer
X -- Ethylene Oxide Polymer
Y -- Carboxyl Polymer
2 -- Biocolloid + Inorganic Coagulant + Caustic Soda
3 -- Hydrophylic Colloid + Pregelatinized Starch in Alkalai
4 -- Aluminum Hydroxide + Complex Organic Polymer
5 -- Alumina + Polymer + Caustic Soda
6 -- Polyacrylic Acid or Polyacrylate of Sodium or Ammonium
7 -- Aluminum Hydrate + Caustic Soda
8 -- Alkalai Concentrate + Metallic Ions
9 -- Chemically Modified Natural Polymer

APPENDIX III

Chemical Flow

CHEMICAL FLOW

A. Soft flakes, may hang up if packed excessively in a confining area, otherwise free flowing. Usually will not need aid (vibration or agitation).
B. Powdered, soft flakes, hang up if packed excessively in a confining area, may or may not need aid according to rate of feed, etc.
C. Soft granules, sometimes fibrous or flattish, may hang up if packed excessively in a confining area, otherwise free flowing. Usually will not need aid.
D. Powdered, soft granules, sometimes fibrous or flattish, hang up if packed excessively, may or may not need aid, according to other factors.
E. Granular, fluid powder, will arch if packed and can be fluidized or is floodable (to very floodable.) Needs aid and may need rotor, according to rate, etc.
F. Granules and powder, will arch and can be fluidized. Needs aid and could need rotor, etc.
G. Cohesive powder and granules, will arch, but will not flood. Needs aid.
H. Cake up of room relative humidity.
J. Tendency to cake (or mass) at higher relative humidity.
K. Cake at higher relative humidity.
L. Moisture absorption, may lessen flowability.
M. Practically no dust.
N. Very little dust.
P. Some dust.
R. Dusty.
S. Very dusty.